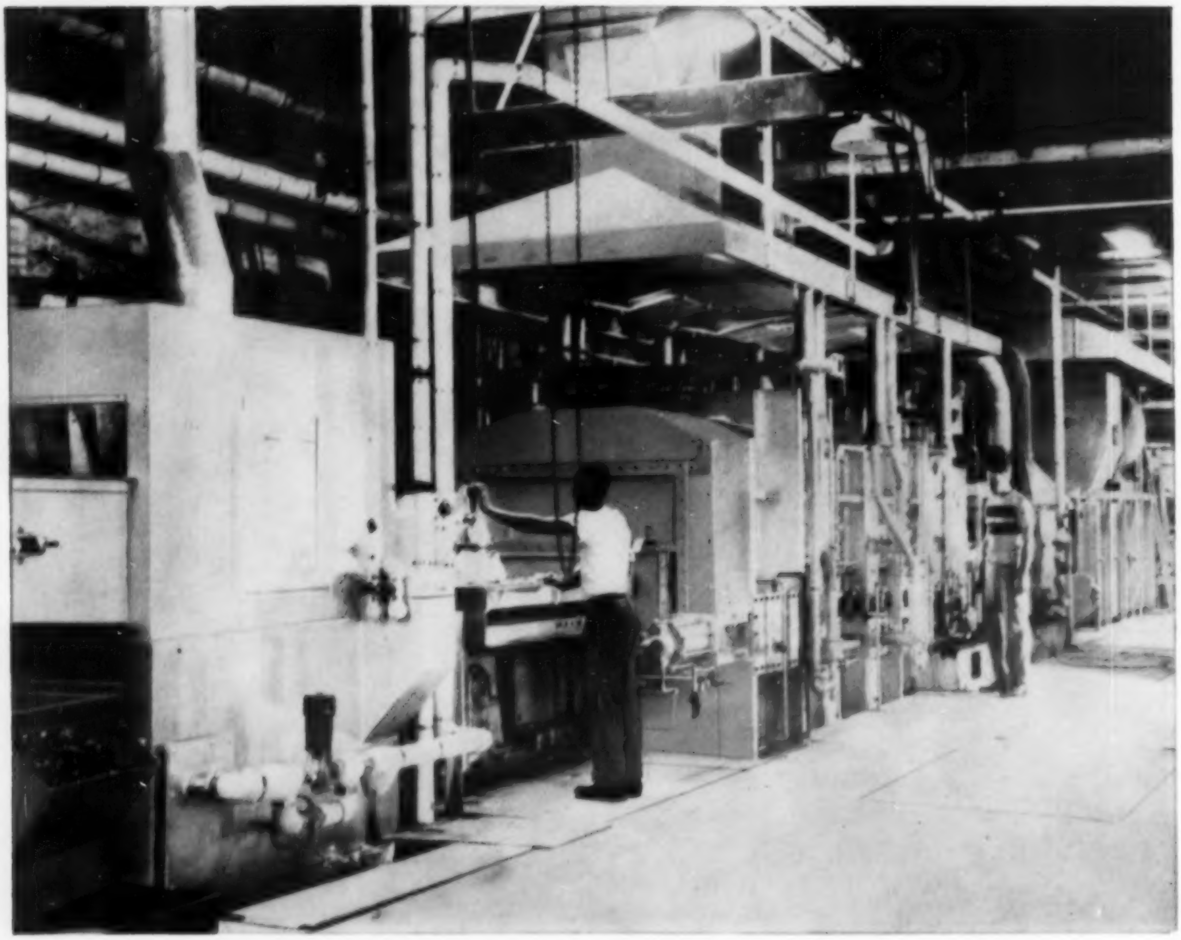
METAL PROGRESS



Production increased 500% with automatic harden-draw lines

Many things improved when two of these Surface lines were installed by a fastener manufacturer: production (up 500% over previous methods), delivery time, and product quality and uniformity. Either large runs, up to 50,000 fasteners, or small batches of special parts are processed economically. All operations—weighing, loading, first wash, clean hardening, quench, second wash, draw, and rust-proofing—are tied together by timed conveyors and feeders. Surface RX® generator gas permits carburizing as well as clean hardening.

This is one of many demonstrations that Surface automatic heat treating can help you get the most for your production dollar.

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Surface® Heat Treat, Steel Mill, Glass Divisions • Kathabar® Air Conditioning Division • Janitrol® Aircraft-Automotive Division • Janitrol® Heating & Air Conditioning Division • Webster Engineering Company: Boiler Burner Division

Surface®
HEAT TREATING EQUIPMENT

Metal Progress

Volume 70, No. 5

November . . . 1956

Inspired by the extrusion operation, this month's front cover was designed by WALLACE ABNEY, and won honorable mention in the annual *Metal Progress* competition at Cleveland Institute of Art.

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READERSHIP RESEARCH

*The coding symbols refer to the ASM-SLA Metallurgical Literature Classification.

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As I was saying...

—after President Schaefer read the citation awarding to me the Gold Medal at the Annual Banquet in Cleveland on Oct. 11:

"Mr. President: I am indeed truly honored and grateful for the distinguished and signal honor you have conferred upon me. I realize how unworthy I am to be the recipient and custodian of this medal.

"While it is true I have expended a lifetime of service with the Society, it has been a labor of love. At the same time it has been a greatly rewarding experience as I have observed and counted the steps of progress from a lowly beginning to the top of the path of accomplishments where we may now peer into the future and envision the broad field of usefulness of the A.S.M. to the great metal industry. It is a vista not of today or tomorrow or for a few years to come—but a vision into the far future, the next 100 years at least, wherein the A.S.M. will become an ever-increasing agency of advancing educational standards and activities to the metals industry as long as that industry is a part of the national economy.

"It will not be within the life span of those here this evening to witness to completion the changing scene because the A.S.M. will never have completed its term of usefulness and service. But you who are here should take just pride in the fact that you have helped set the sights and launched the A.S.M. OF TOMORROW on the sea of service.

"I am very humble indeed, President Schaefer, at the compliments so liberally bestowed in this citation as well as the magnanimous treatment Mill and I have always received from the officers and trustees of the Society. The thoughtful consideration of the present Board has been especially heartwarming and sincerely appreciated.

"But I must re-emphasize at this moment a statement I have made on many previous occasions — that the stature of the A.S.M. of Today is not and never could be the accomplishment of a single individual. The A.S.M. of Today is the handiwork of thousands of hard-working, self-sacrificing, enthusiastic members of A.S.M. who have labored since its foundation to the present. It is they who have caused the crown of success to be placed on the Society.

"And so, President Schaefer, I accept this Gold Medal and will hold and treasure it, in trust, and in loving memory, as a living and enduring recognition of the valuable contributions and untiring efforts of the thousands of members — both then and now — who, with the capable assistants with which I have been associated (most for many years) have played a major role in placing the Society in the position to carry on — with speed and dispatch — into the A.S.M. OF TOMORROW.

"Mr. President, with a heart full of gratefulness to the Board and to our friends, you may be sure this night will live forever in the memories of Mill and Bill."

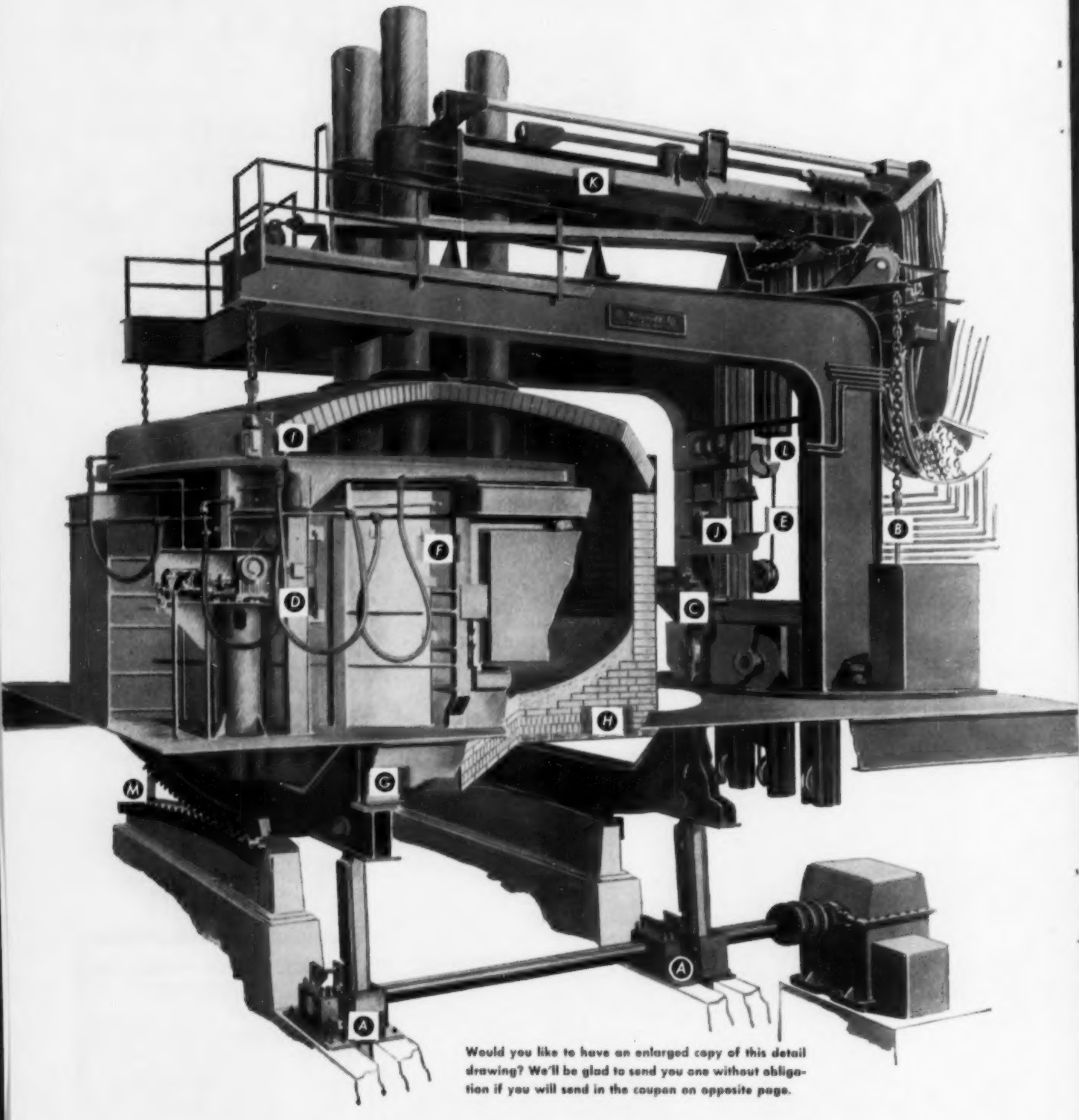
For us it was indeed a memorable occasion!

Cordially,

Bill

W. H. EISENMAN, *Secretary*
American Society for Metals

Ten (10) reasons why is the finest electric furnace



Would you like to have an enlarged copy of this detail drawing? We'll be glad to send you one without obligation if you will send in the coupon on opposite page.

We welcome an opportunity to help you select and install the Heroult Furnace best suited to your requirements. Remember—*the Heroult we make and install for you will be the finest electric melting furnace that money can buy!*

Parts to be hardened are suspended

Whatever your furnace needs for control—

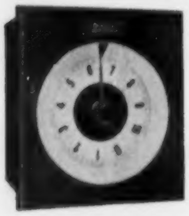
There's good reason why more heat-treating furnaces everywhere are controlled by Brown instruments. First, of course, is performance . . . sensitive, precise control that meets the most exacting requirements of modern heat-treating techniques. And equally important is versatility. In this varied line of instrumentation you'll find just about everything a furnace could possibly need in the way of control.

Choose *ElectroniK* Strip Chart Controllers for detailed, long-term records . . . and a selection of control forms including electric systems of the contact, position-proportioning (*Electr-O-Line*) and time-proportioning (*Electr-O-Pulse*) types; and pneumatic control from two-position to full proportional-plus-reset-plus-rate action.

Choose *ElectroniK* Circular Chart Controllers for ease of scale reading . . . convenient daily charts; in a full range of electric and pneumatic control forms.

Note: the basic components of **all** *ElectroniK* models are interchangeable . . . to simplify and speed up service.

Choose *ElectroniK* Circular Scale Controllers where you want readability and control check at extreme distance . . . without need for a record. Supplied with all contact and proportional types of electric control.



Note: **all** *ElectroniK* models are available in both Standard and Precision Series.

Choose *Pyr-O-Vane* Controllers where you don't need a record but do need precise vane type snap action electric control by a millivoltmeter instrument... also available with pulse-type time proportioning action, in both vertical and horizontal models.

Choose the *Protect-O-Vane* Safety Cut-Off for simple, dependable excess temperature protection ... can be used with any temperature control to prevent furnace shut downs and loss of production.

• • •

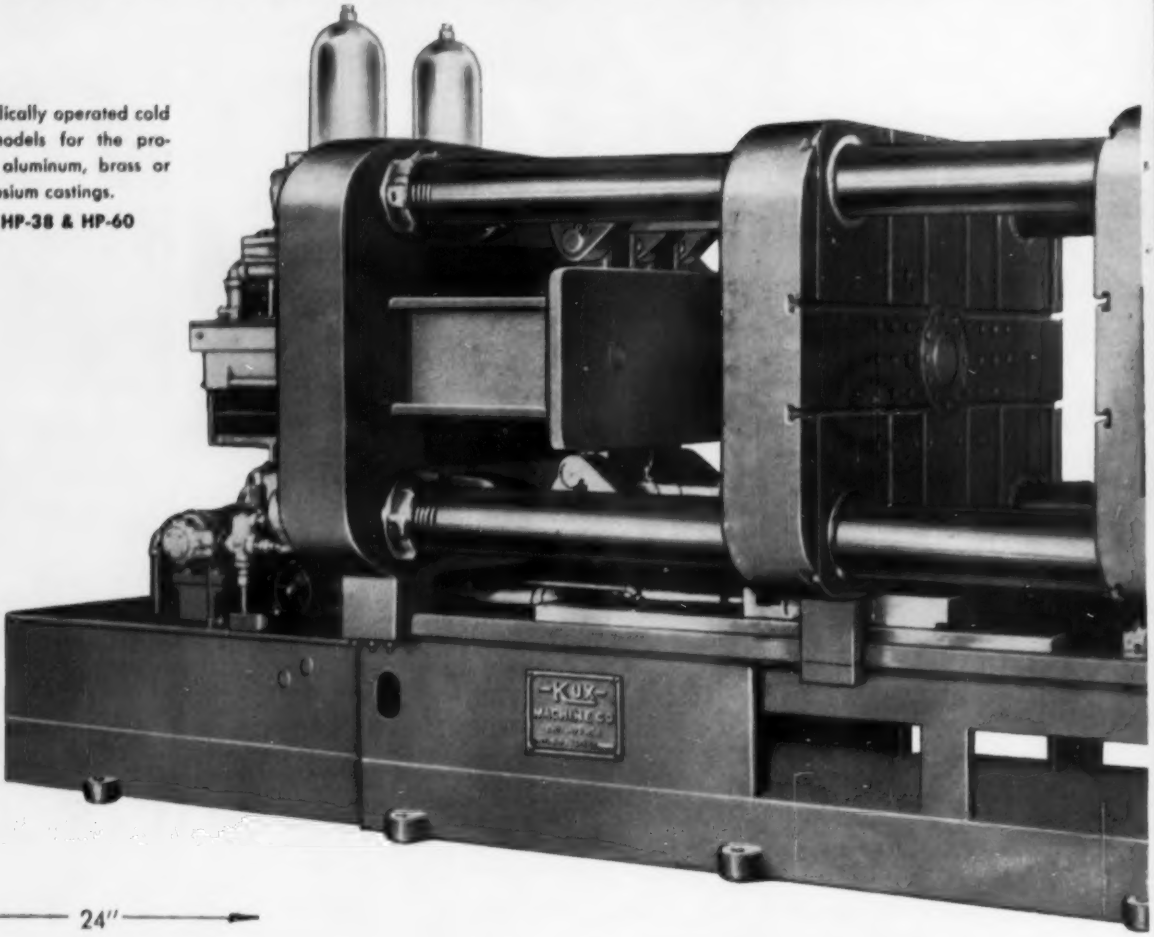
And . . . for all your pyrometer supplies, investigate the convenience and economy advantages of the HSM Plan.

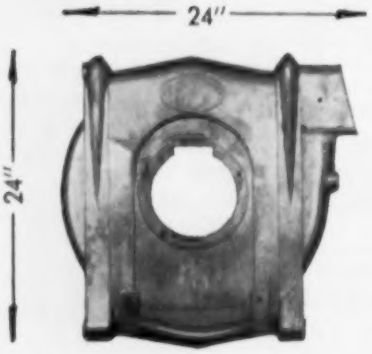
Giant vertical drop-bottom furnace kept accurate to 5°...

One operator easily puts the furnace through its paces. The furnace, designed by Loftus Engineering Corporation, has 752 cubic feet of working space.

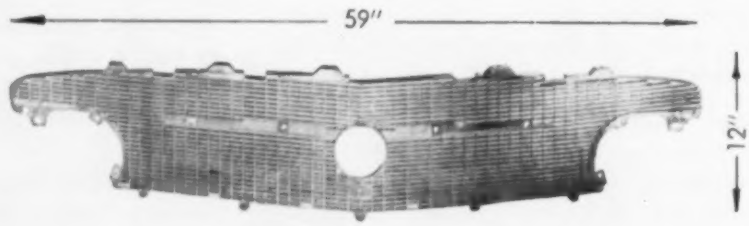
The mammoth Kux

*Kux hydraulically operated cold chamber models for the production of aluminum, brass or magnesium castings.
Models HP-38 & HP-60





Rotary lawn mower housing, a one piece aluminum die casting produced on the mammoth **Kux Model HP-38**



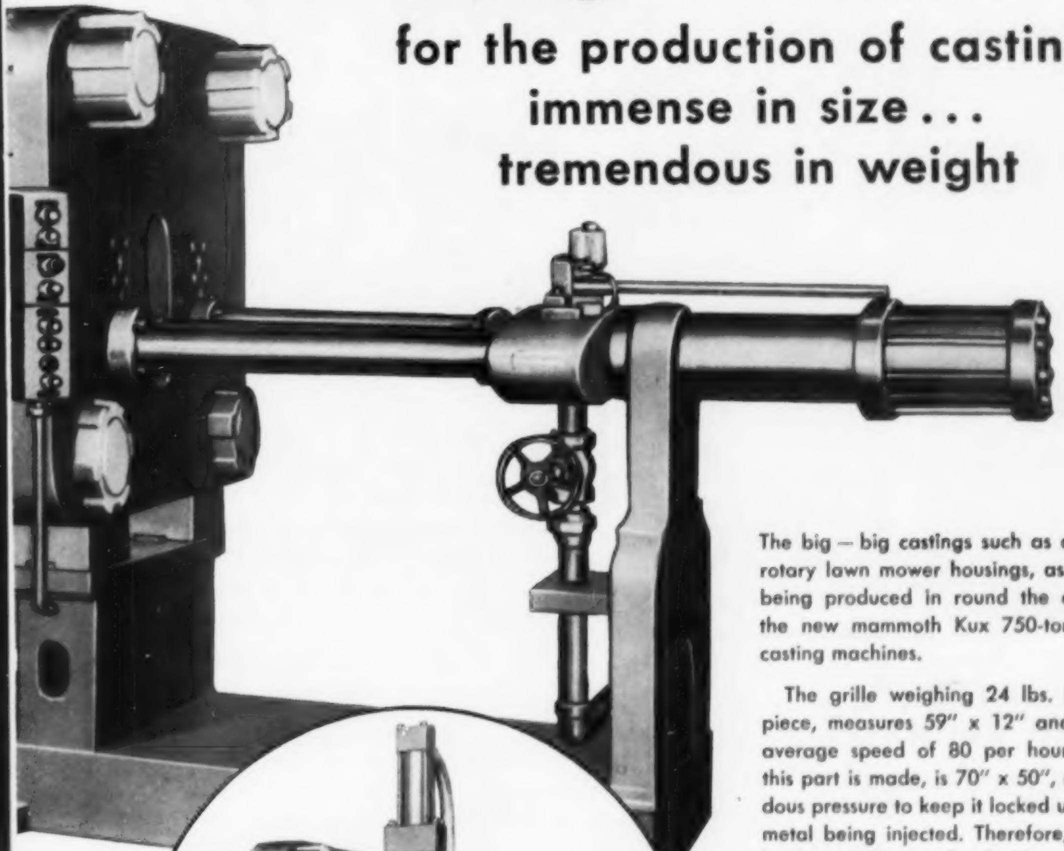
Automobile front grille cast in one piece in zinc on the mammoth **Kux Model BH-60**

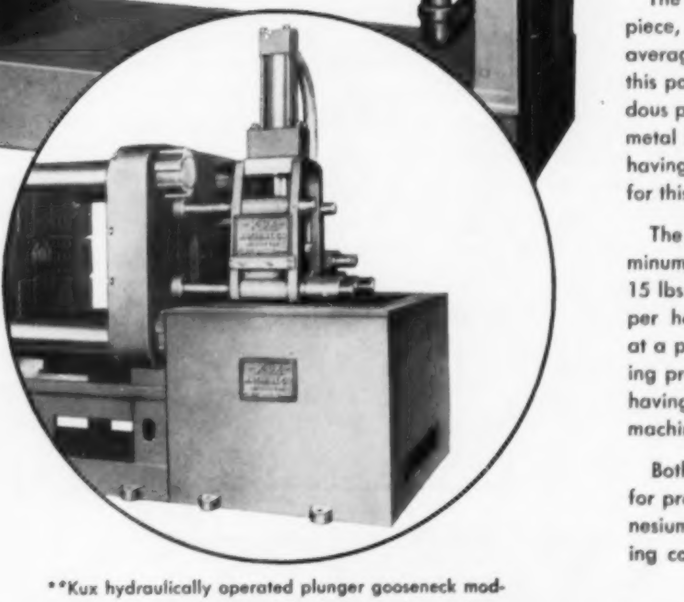
ILLUSTRATED ARE ONLY TWO MODELS OF A FULL RANGE OF KUX DIE CASTING MACHINES FROM 25 TONS TO 1000 TONS.

KUX MACHINE COMPANY • 6725 North Ridge Avenue, Chicago 26

750-ton and 1000-ton die casting machines

for the production of castings immense in size . . . tremendous in weight





The big — big castings such as automobile grilles or rotary lawn mower housings, as illustrated, are now being produced in round the clock operations, on the new mammoth Kux 750-ton and 1000-ton die casting machines.

The grille weighing 24 lbs. in zinc, cast in one piece, measures 59" x 12" and is produced at an average speed of 80 per hour. The die, in which this part is made, is 70" x 50", and requires tremendous pressure to keep it locked under the force of the metal being injected. Therefore, the BH-60 machine having 1000-ton die locking capacity is utilized for this all powerful job.

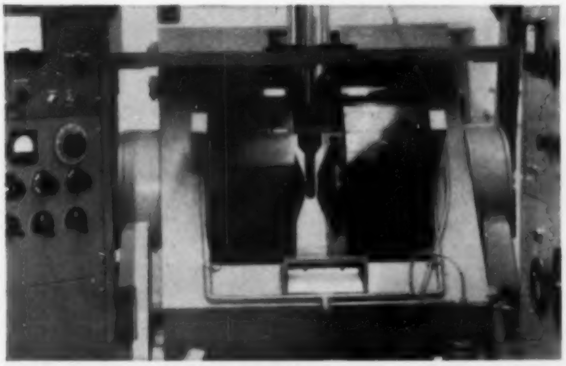
The rotary lawn mower housing, a one piece aluminum die casting measures 24" x 24" and weighs 15 lbs. Produced at an average speed of 60 castings per hour, with the aluminum injected into the die at a pressure of more than 5000 lbs. PSI, a die locking pressure of 750 tons is required. Thus the HP-38, having this capacity, has proven to be the ideal machine to accomplish this die casting job.

Both sizes are available as cold chamber models* for producing castings from aluminum, brass or magnesium, or as plunger gooseneck models** for making castings from zinc, lead or tin alloys.

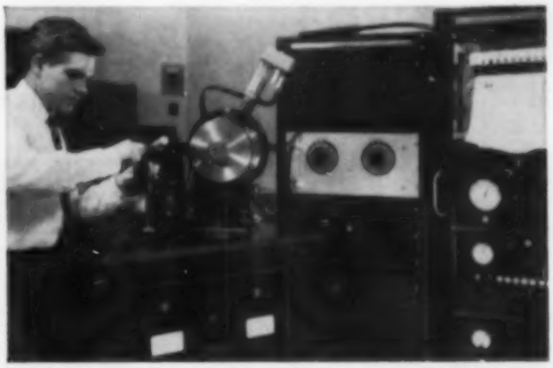
**Kux hydraulically operated plunger gooseneck models for the production of lead, tin or zinc castings

Models BH-38 & BH-60

KUX MACHINE COMPANY • 6725 North Ridge Avenue, Chicago 26



Graphite must pass good-conduct test. A tiny graphite crystal is chilled to within one degree of absolute zero, then held between poles of a powerful electromagnet, while electrical conductivity is measured in each crystalline direction — one of many ways to learn more about carbon.



X-ray "scatter" test reveals secrets of graphite. Testing the x-ray diffraction of carbon and graphite samples gives researchers a picture of relationships between crystals in carbon and graphite materials. This is another experimental method for probing the mysteries of carbon.

break-through in carbon physics research

promises future advances in furnace electrodes, linings, carbon brushes and other needs of the metal industries

One more barrier is down. And science strides forward in the age-old quest for deeper knowledge of carbon, one of nature's more complex puzzles.

This barrier—the inability to get large graphite crystals pure enough for experimental needs — has now been overcome by researchers of National Carbon Company. Their new annealing techniques, which remove impurities from large graphite crystals, also eliminate imperfections and weaknesses in the crystalline structure.

Several research teams at the new Parma laboratories are exploiting this break-through of science. The purified crystals are being subjected to a variety of experimental tortures—electrical, magnetic and thermal. Fundamental facts about the behavior of the single graphite crystal are being gathered and pieced together like jigsaw cutouts—building up a more complete and systematic picture. In this way, our scientists will be better able to *predict* the properties of new carbon and graphite materials.

The work on single graphite crystals is only one phase of a broad research program in carbon physics. The metals industries, as large users of carbon and graphite products, will share in the gains from this work of science at the outer boundaries of knowledge. Write for new booklet titled "Research," telling more about the work at the new Parma laboratories.

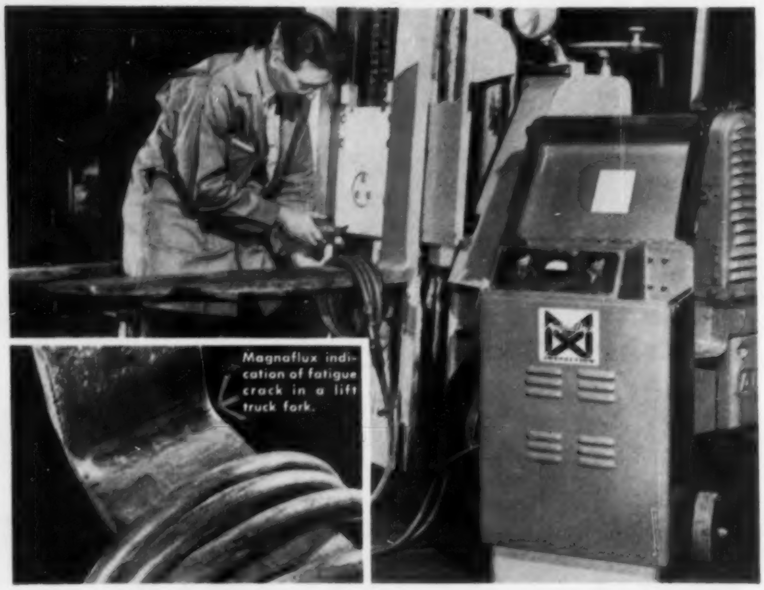
Look to **NATIONAL CARBON**
for leadership in carbon and graphite products

NATIONAL CARBON COMPANY • A Division of Union Carbide and Carbon Corporation UCC ***30 East 42nd Street, New York 17, N. Y.***
Sales Offices: Atlanta, Chicago, Dallas, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco. *In Canada:* Union Carbide Canada Limited, Toronto

Case Studies:

NONDESTRUCTIVE TESTING SYSTEMS

THE ELECTRIC DETECTIVE is an apt description of the Magnatest FM-100 Conductivity Meter. Magnatest uses the electrical conductivities of materials as a measure of uniformity, hardness, purity and other characteristics. A small hand held coil induces eddy currents in the test material, which in turn affect the impedence of the coil in proportion to the conductivity of the material.



IT'S JUST A LITTLE CRACK, but it's a serious matter when it shows up on an industrial crane hook. In fact, to the naked eye it may appear to be a scratch, at most. Yet it can open further and further under load. The end result: failure in service and subsequent costly damage. Photo above shows a Magnaflux indication of such a crack in a crane hook.

How Periodic Inspection Ups Production by Preventing Equipment Failures

When industrial equipment fails in use, it usually results in lost time, production, or even life! In each case there is a corresponding loss of money. The amount, of course, depends upon the circumstances. Periodic inspection with an M testing system can foretell the exact nature and extent of structural weaknesses in your machinery, tanks, or equipment.

Invisible hairline cracks are warning signs of future fatigue failure. The M tests detect such signs in any material. You can take the proper corrective steps in time to prevent costly production interruptions. Nondestructive testing can help you eliminate profit-draining equipment failures. —Investigate Magnaflux inspection methods today!

ZYGLO "SPOTLIGHTS" SERIOUS DEFECTS IN CUTTING TOOLS

Zyglo inspection employs an oil base penetrant that is brilliantly flourescent under "black light". It detects surface cracks or pores when they may affect the service life of any metal part. Whether you produce cutting tools, or use them, Zyglo provides better inspection at lower cost.

THE HALLMARK OF THE BEST SYSTEMS FOR NONDESTRUCTIVE TESTING

Write for complete details concerning any of the above case studies, or ask for our new booklet on "Lower Manufacturing Costs."

Take Your Inspection Problems to the House of Answers

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SINK DIES FASTER in FINKL Die Blocks with

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FINKL

Machining time, such as planing, rough cutting, milling, hand benching and burring are appreciably reduced on Finkl SMQ Die Blocks. Thorough field testing shows that the Special Machining characteristic of SMQ saves shop time and gets the die into production sooner.

There is a Finkl steel available for any forging need. All are quality controlled through each step from our own melt shop to final inspection.

When you next consider die blocks, your local Finkl representative will gladly help you plan for "impressions that last."

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HOT WORK STEELS
•
FORGINGS
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ELECTRIC FURNACE STEELS

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A. Finkl & Sons Co.
2011 SOUTHPORT AVENUE • CHICAGO 14

APPLICATION and EQUIPMENT new products

Continuous Furnaces

Continuous carbon tubular element furnaces with tube size up to 6 in. i.d. have been announced by the Harper Electric Furnace Corp. This type of furnace permits uniform heating of work within a graphite tubular resistance element in which temperatures up to 5000° F. can be indefinitely maintained. The new furnaces

feature continuous operation with automatic mechanical pusher, entrance preheating chamber, and water cooled cooling chamber. Purge chambers may be added to maintain low dew-point reducing atmospheres. Overall length of the largest unit is 28 ft. Research models with tube diameters down to 1 in. are also available.

For further information circle No. 1245 on literature request card, p. 48-B.

Industrial Radiography

Four new portable industrial X-ray units for the radiographic inspection of castings, welds and assemblies have been announced by Mitchell Radiation Products Corp. All units are protected against mechanical and electrical failure and are adaptable to most voltages encountered in industrial plants. KV

range for the model MS-200 is 55 to 200 kvp; 70 to 260 kvp. for the MS-260 and 70 to 300 kvp. for the MS-300. MA ranges are 1 to 5. Maximum steel penetration for the MS-200 is 2¾ in., MS-260, 4 in., and MS-300, 5½ in. Maximum power consumption is 1050, 1450 and 1700 watts.

For further information circle No. 1246 on literature request card, p. 48-B.

Automatic Inspection Units

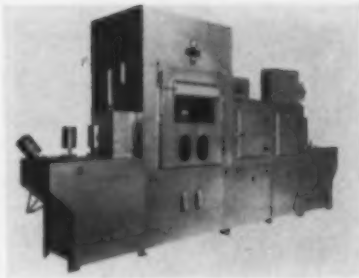
A new and automatic inspection unit for nonmagnetic rod, wire, tube, and bar has been announced by the Magnaflux Corp. The new instrument automatically detects such problems as seams, overlapping, diameter changes, inclusions, voids, concentrated porosity, metallurgical variation, and splits. It is suited for high

speed plant operation. The FW-400 is a series of instruments designed to cover the range of nonmagnetic materials from aluminum, brass, and copper to tungsten, austenitic stainless, and titanium in a range of diameters from 1/64 in. to 3 in.

For further information circle No. 1247 on literature request card, p. 48-B.

Blast Cleaning

A new automatic wet blast unit has been announced by the Cro-Plate Co., Inc. The unit is designed for the elimination of wire brushing on cast iron and aluminum pistons ranging up to 42 lb. in weight. Pistons are manually loaded on revolving work-



holding spindles mounted on the stainless steel conveyor chain and indexed first into the wet blast position where oscillating guns blast the entire outside area. Next the pistons move into the rinse compartment where they are flushed free of residual abrasive. From the rinse they enter the rust prevention station where the cast iron pistons are sprayed with a water soluble oil.

For further information circle No. 1248 on literature request card, p. 48-B.

Low-Temperature Cabinet

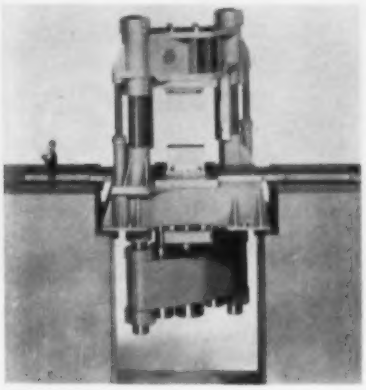
A new low-temperature chilling machine with a 4 cu. ft. chamber has been announced by Cincinnati Sub-Zero Products. The new unit for laboratory testing has a net thermal capacity of approximately 600 Btu. per hr. at —120° F., with a temperature selection from +80 to —120° F., and

full-range pull down in 45 min. The chilling chamber, 18 in. high by 18 in. wide by 17 in. deep, is made of electric-welded, pressure-tight 14-gage steel, hot dip zinc coated.

For further information circle No. 1249 on literature request card, p. 48-B.

Forging Press

A 2000-ton self-contained hydraulic forging press has been announced by Lake Erie Engineering Corp. Built for Allegheny Ludlum Steel Corp., the single-action press is of a pull-down, 2-column design and operates at 60 planishing strokes or 30 forging strokes per minute. The center cylinder and the two side cylinders governing the pull-down action are inserted in the lower crosshead. Two cylinders



inserted in the bed platen interact with the pistons coupled to the upper crosshead for push-back action. 20 pumps, each having a capacity of 34.9 gal. per min. of turbine oil at 4420 psi. are driven by 10 double-end, 150 hp., 1200 r.p.m. motors. This equipment is located away from the press while a pressurized prefill tank is mounted at the press and is connected directly to the press by a large diameter pipe.

For further information circle No. 1250 on literature request card, p. 48-B.

Abrasive Throwing Wheel

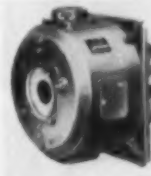
A new type of wheel for centrifugally propelling abrasive in airless blast cleaning has been announced by Wheelabrator Corp. It is available for use on airless abrasive blast cleaning equipment already installed in plants, as well as on machines being manufactured. It comes in the 2½ in. wide by 19½ in. diameter size. A new method of holding the wheel blades in the wheel has been used.

Whereas a set screw and screw bushing were formerly used for this purpose, the new wheel employs a spring arrangement. The new locking device is not in the abrasive blast stream nor subject to any appreciable wear.

For further information circle No. 1251 on literature request card, p. 48-B.

Blended Flame Unit

Hauck Mfg. Co. has announced a new device to insure complete fuel combustion and obtain better circulation of heat at temperatures of 400 to 1800° F. in industrial furnaces, ovens, kilns and other heat processing equipment. By diluting the high temperature combustion products by thoroughly blending them with excess air, these products are increased in volume while their average temperature is reduced. Thus with this expanded value of gases, circulation and distribution of heat is improved, with greater uniformity of temperature throughout the heating chamber. The unit is designed to assure a stable flame and prevent the entry of excess air from interfering with the ignition and combustion of the fuel within the refractory tile. The excess air flow is outside the tile, so that blending takes place only at the tile outlet and periphery of flame. The unit consists of a cast iron mounting head and plenum chamber with inlet for blending air, burner mounting bolts, and a refractory ignition tile within a stainless steel shell.



For further information circle No. 1252 on literature request card, p. 48-B.

Tin Plate

Somers Brass Co. has announced a new hot tin plate process which will provide the smooth surface, solderability, adherence and complete absence of slag essential to manufacturers of printed circuits, capacitors, and cable wrappings. Tin coatings of 0.00002 to 0.00008 in. and 0.0002 to 0.0003 in. are available on brass, copper, bronze and other thin strip metals in gages from 0.012 down to 0.002 in., widths from ⅛ to 6 in. and wider.

For further information circle No. 1253 on literature request card, p. 48-B.

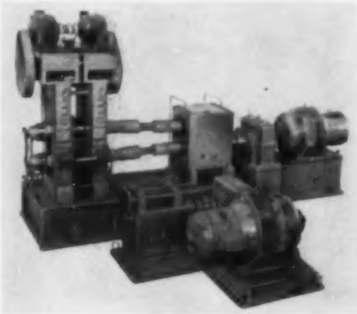
Bondable Plastics

Both Teflon and Rulon are now being surface-treated by Dixon Corp. to enable these anti-hesive substances to bond with other materials such as metals, wood, other plastics and cloth. The surface treatment may penetrate the material to a depth of 0.001 to

0.003 in. Either part or all of any surface can be treated, so that only a portion can be bonded and the balance will retain its non-adhesive properties. Flat shapes can be treated on either side or on both sides as required.
For further information circle No. 1254 on literature request card, p. 48-B.

Laboratory Rolling Mill

The Fenn Mfg. Co. has announced the new, large combination laboratory mill which will take heavy reductions



on ferrous strips at all speeds between 100 and 500 fpm. It can be used as a two-high mill, or as a four-high mill featuring driven back-up rolls or work rolls. Many drive combinations can be incorporated to meet customer specifications and the mill can be powered to take reductions up to 0.080 in. per pass on ferrous strip. Maximum torque is 21,000 lb.-in. when the mill is work roll driven, and 120,000 lb.-in. when used as a two-high mill or back-up roll driven four-high mill. Maximum separating force is 300,000 lb. at 100 fpm.
For further information circle No. 1255 on literature request card, p. 48-B.

Heat Treating Baskets

A steel basket, specially constructed for moving heavy aluminum castings to and from heat treating furnace and quenching tanks, has been announced by Wiretex Manufacturing Co. The structure of the basket, with its four lifting hooks, makes it easy to lift the castings by means of a movable crane. A specially con-

structed door in the front of the basket facilitates unloading. Made of steel, the basket measures 84 by 60 by 51 in. deep.
For further information circle No. 1256 on literature request card, p. 48-B.

Cadmium Plating

R. O. Hull & Co. has announced four new products for cadmium plating. Super XL cadmium brighter is an addition agent for cyanide cadmium plating. Only small amounts are needed in the bath. In addition to brightness, Super XL minimizes cadmium usage by improving uniformity of deposit with fastest production. Cad-Sol is a concentrated solution of cadmium cyanide for make-up or maintenance of cadmium plating baths. Cadip is used in small additions to the final hot water rinse to speed drying and to prevent discoloration of cadmium deposits. Rodip CD-3 and CD-4 are single, short-dip chromate post-plating treatments.
For further information circle No. 1257 on literature request card, p. 48-B.

Temperature Control

Three-position pyrometer temperature controllers have been announced by West Instrument Corp. These controls may be wired for a wide variety of specialized control applications: heating with automatic cooling; motor

operated fuel valve; high-low-off or high-low-medium electric or fuel systems; control with high limit feature and automatic reset. One, with a single setting pointer, permits no more than 1% of scale range as neutral. The other, with two settings, permits spread up to 20% of range.
For further information circle No. 1258 on literature request card, p. 48-B.

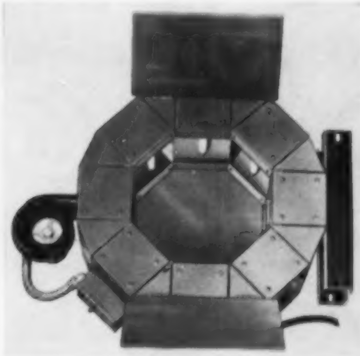
Abrasive

A new aluminum oxide abrasive produced by a special new electric furnace process has been announced by Norton. It has been subjected to honing stick, centerless grinding, cylindrical and internal grinding, and thread grinding tests and good results are claimed. Such advantages as longer life, holds form longer, more work-pieces per dressing, better finish, faster cut, cooler cut, and more pro-

duction per wheel are claimed for 44 Alundum grinding wheels.
For further information circle No. 1259 on literature request card, p. 48-B.

Infrared Oven

Fostoria Pressed Steel Corp. has announced radiant heating units designed for research and testing purposes. Thin quartz lamps provide an intensity of 100 watts per inch of



lamp length. The illustration shows a small quartz lamp oven, 16 in. deep with an opening of 13½ in. It holds eight 1600-watt quartz lamps. Oven temperatures of approximately 1000° F. are possible.
For further information circle No. 1260 on literature request card, p. 48-B.

Portable Indicator

A new portable potentiometer indicator has been designed by Thermo Electric Co. MiniMite weighs under 4 lb. and measures about 4 by 5 by 6 in. It has a scale 23½ in. long. Standard double - scale range is 0 to 1800° F. for iron-constantan and 0 to 2400° F. for chromel - alumel.

Major graduations are in 100° F. for both calibrations while minor graduations are in 5° F. for iron-constantan and 10° F. for chromel-alumel.
For further information circle No. 1261 on literature request card, p. 48-B.

Metal Finish

The Conversion Chemical Corp. has announced a new commercial metal finish for zinc and cadmium die castings. Dull black finish provides corrosion resistant properties when applied on the appropriate conversion coating. The base chromate coating of a metal to be finished can be made thicker, denser, and harder than that

CUT COSTS

save – the Grainal way!

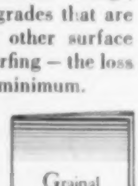
Vancoram Grainal Alloys are reliable, produce remarkably consistent results . . . *and they're economical.*

The reliability and efficiency of Grainal Alloys for improving hardenability have been proved in millions of tons of boron steels. What's more, Grainal Alloys can be incorporated into conventional steelmaking practices with no major changes.

In stainless and heat-resisting steels, small additions of Grainal Alloys improve hot-working characteristics, cut conditioning costs and rejections. That adds up to important savings, especially in the higher alloy grades that are prone to develop cracks and other surface defects. Grinding, chipping, scarfing – the loss of good metal can be kept at a minimum.

For complete information on Grainal Alloys and other Vancoram products, contact your nearest Vanadium Corporation District Office.

Write today for your free copy of "Grainal and Its Use."



1906 1956

VANADIUM CORPORATION OF AMERICA

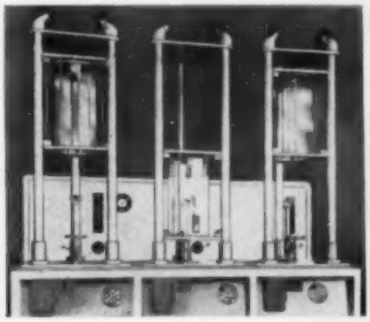
420 Lexington Avenue, New York 17, N. Y. • Pittsburgh • Chicago • Detroit • Cleveland

Producers of alloys, metals and chemicals

obtained by previous methods, with resulting greater absorption of Kenvert #11-B.
For further information circle No. 1262 on literature request card, p. 48-B.

Induction Heating

Lepel High Frequency Laboratories has announced a production fixture to braze metal assemblies without the use of flux, by induction heating under a controlled atmosphere. This unit can join copper alloys, steel and stainless steel assemblies on a production basis. The three work stations are operated from a single induction heating unit. High frequency current is fed to the work coils through coaxial leads. The proper atmosphere is obtained by directing a continuous flow of purified gas into the glass or plexi-glass bell. The flow of gas is controlled by the flow meters at each of the three work stations, allowing the gas to enter through the top, spreading over a diffusion plate and escaping through the bottom. The glass bells are counter-weighted to move freely on the posts to facilitate the handling of the work.



For further information circle No. 1263 on literature request card, p. 48-B.

Threading Tool Holder

A single-point threading tool holder for use in a reversing lathe has been announced by Easco Products. The tool bit employed in this new holder is secured in a head that rides on a cone point in the main tool body and is backed by a ball joint at the rear. The cone extends down through the body to a stud on which a cylindrical collar is threaded and adjusted to required height to support the point during the forward cutting stroke. Reversing the lathe causes the cutting point and upper anvil to raise slightly to take care of backlash. This movement also permits the tool bit to turn to the helical angle of the thread and follow the thread back to the starting position without dragging. At this point the upper anvil drops back into engagement and is

ready for the next cutting cycle. Micro switches can be set to limit the forward and reverse travel of the carriage, making this threading operation fully automatic.

For further information circle No. 1264 on literature request card, p. 48-B.

Automatic Micrometer

A new Carson-Dice digital read-out electronic micrometer has been announced by J. W. Dice Co. It interprets a dial or scale position into the digits or a decimal dimension. Setting the instrument is effected by an electronic circuit between the micrometer anvil and the work before any pressure is built up on the work by the micrometer screw. A motor drive automatically brings the micrometer precisely to the point of

contact at a speed far faster than can be done manually. The digital readout counter on the front of the instrument displays the exact reading in 0.0001 in. The Model HDR has a measuring range of 1 in. (⅞ in. with standard micrometer tip), and a throat depth of 2 in. Upper head is adjustable in height to accommodate work up to 2 in. Standard anvil is readily removed for use of special fixtures.

For further information circle No. 1265 on literature request card, p. 48-B.

Stripper

Kolene Corp. has announced a patented salt formula for stripping plastisol from steel. Only 4 min. im-

mersion in this salt bath strips 2¼ lb. of plastisol from the baskets illustrated. Baskets are lowered into the bath by an overhead crane, then transferred to an adjoining water-rinse tank after stripping. Residue settles into a removable sludge pan at the base of the pot. Average weight of the coated baskets is 12¾ lb.

For further information circle No. 1266 on literature request card, p. 48-B.

Scale Remover

Enthone, Inc., has announced the availability of a new product for the electrolytic removal of scale and oxides from iron and steel. Alka-Deox 109 is a white alkaline used in water solution with sodium cyanide. It will not chemically attack the iron or steel because of the alkaline nature of the chemical. It is adaptable to plating lines and automatic equipment involving alkaline or alkali-cyanide plating solutions.

For further information circle No. 1267 on literature request card, p. 48-B.

Electric Furnaces

A new development in electric furnaces with gas tight controlled atmosphere has been announced by the Waltz Furnace Co. Elements are formed of 80-20 chromium-nickel ribbon of extra large cross section. They are formed in loops and are slid into grooves in the refractory lining. The

elements operate on 110 volts by means of transformers installed in the base of the furnace. These transformers have either 220 or 440 volt primary and 110 volt secondary. The doors are air-operated by means of a foot valve, which enables operator to easily open the door and stop it in any desired position by foot pressure.

For further information circle No. 1268 on literature request card, p. 48-B.

Belt Grinder

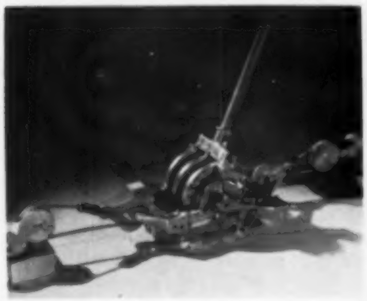
For high-speed precision grinding and finishing of outside diameters, a new automatic rotary abrasive belt grinder has been announced by Engelberg Huller Co. It will handle circular parts from 26 to 40 in. in diameter, and can be modified to meet other diameter ranges. The work table rotates at standard speeds of either ¾ or 3 revolutions per minute, with optional change gears

for other r.p.m. requirements. Parts are moved back and forth across the belt face by means of an air-hydraulic reciprocating device, with 7-in. oscillation stroke. The table is adjustable from 0 to 45 degrees for angular grinding. Standard abrasive belt size is 8 by 107 in. with belt speed available from 2000 to 5000 s.f.p.m. depending on application.

For further information circle No. 1269 on literature request card, p. 48-B.

Hoisting Device

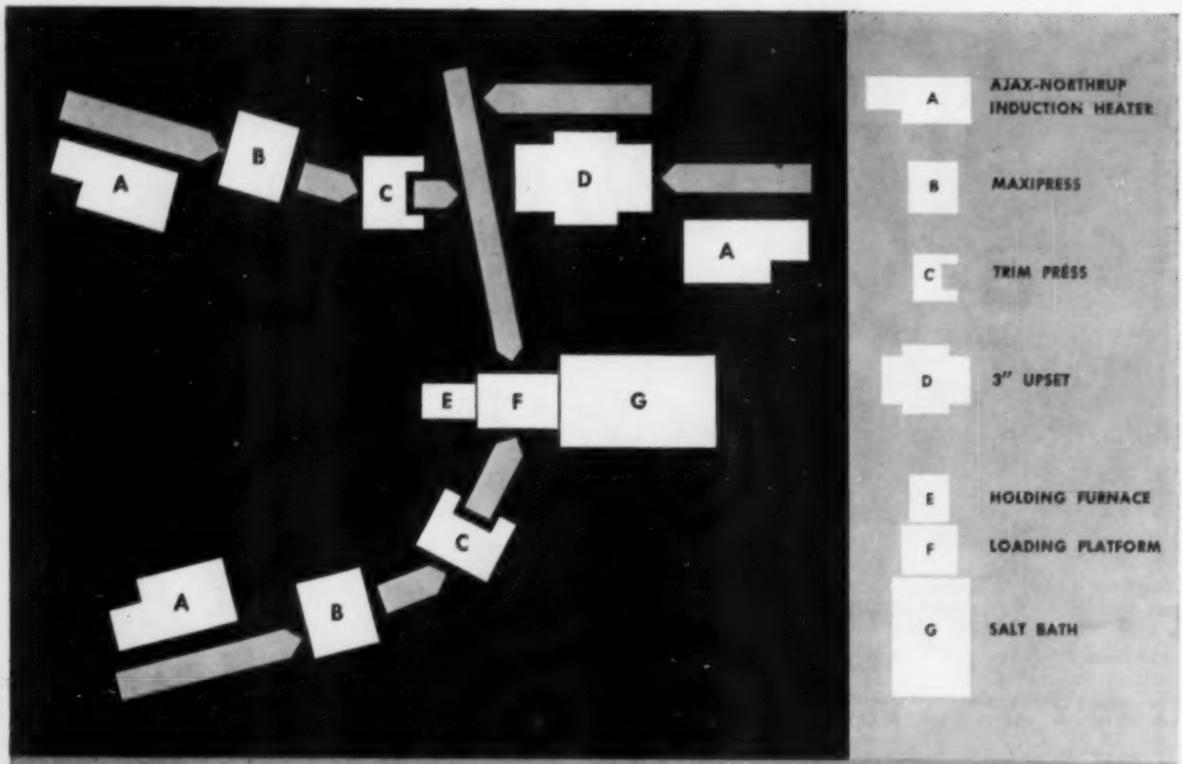
Multiple Corp. has announced a heavy-duty, manually operated power tool designed to lift, lower and pull. The single reel model pulls in one direction only, while the double reel model pulls both directions at one time. Standard ¼ in. 7x9 cables of 7000 lb. capacity are used with stainless steel cable fittings. The double reel model is illustrated.



For further information circle No. 1270 on literature request card, p. 48-B.

Recording Potentiometers

High-speed self-balancing recording potentiometers for use with analog-to-digital conversion devices have been announced by the Bristol Co. Designed to give full-scale traverse in 0.4 sec., the electronic Dynamaster can be equipped with most of the standard digital read-out devices presently available. Round chart models are also available for use where promi-



mechanize forging with induction heat

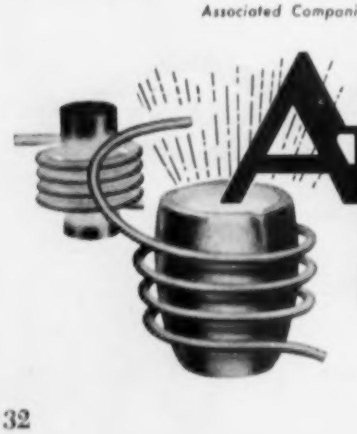
Versatility made Ajax induction heating a natural choice for Massey-Harris' mechanized forge. This one shop handles all the common forging steels, in blanks ranging from one inch rounds to four inch squares, used to make a hundred different automotive and tractor parts. Imaginative forge design, plus the inherent flexibility of Ajax induction heating, make it possible to operate the entire forge with just three induction units . . . each equipped with seven heating fixtures.

The seven fixtures to be used for any given piece can be withdrawn quickly and easily from a "library" adjacent to the forge. Here more than one hundred Ajax-Northrup heating fixtures are completely catalogued and filed in terms of the piece for which they were designed. And the relatively low cost of the fixtures permits Massey-Harris to keep sixty "spares" on hand.

The unusual versatility of this induction heater library is the key to forge mechanization. But Ajax induction heating goes on to pay its way through numerous other advantages. Compared with fuel-fired equipment, for example, induction heating requires less steel, less heating time. There's less scale, dies last longer, rejects are fewer, and working conditions are far better.

Is it any wonder that more forges every day—mechanized or not—are turning to Ajax induction heat? Write Ajax Electrothermic Corporation, Trenton 5, New Jersey, requesting Bulletin 27-B.

Associated Companies: Ajax Electric Company—Ajax Electric Furnace Co.—Ajax Engineering Corp.



AJAX NORTHRUP SINCE 1916

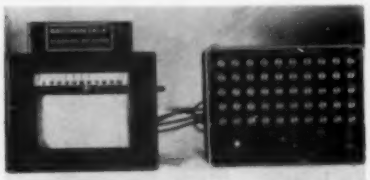
AJAX

INDUCTION HEATING-MELTING

ment indication of the variables is needed while feeding digitized information to data handling equipment. Various pen speeds can be supplied, depending on the speed requirements and type of converter used.
For further information circle No. 1271 on literature request card, p. 48-B.

Strain Gage

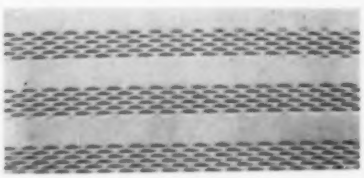
New models of Baldwin 50-point automatic scanning recorders for SR-4 strain gages have been announced by Baldwin-Lima-Hamilton Corp. Either two-arm or four-arm strain gage bridges can be accommodated by proper positioning of a selector switch. Ranges of 0 to 1000, 0 to 2000, 0 to 5000 and 0 to 10,000 micro-inches are provided. Individual



stress-strain curves can be plotted automatically for each channel, making unnecessary the plotting of points in order to analyze test results and permitting immediate information on possible structure failure. To conserve chart paper when less than 50 channels are being scanned, a chart skipping mechanism has been provided. Completion of a sequence of 50 readings requires 30 to 90 sec.
For further information circle No. 1272 on literature request card, p. 48-B.

Patterned Metals

Rigidized Metals Corp. has announced a new process called custom-rold, for the production of patterns in Rigid-tex Metal. By this new method it is possible to roll many standard



patterns in prescribed areas, leaving the remaining portions of the sheet plain. Patterns may be rolled in bands separated by bands of plain metal.
For further information circle No. 1273 on literature request card, p. 48-B.

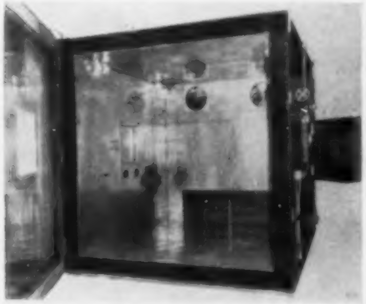
Crucibles

A special new lip that assures faster, more uniform metal flow for crucibles for tilting furnaces has been announced by Electro Refrac-

tories & Abrasives Corp. The lip is suitable for both aluminum and brass pouring. The new lip fits into a grooved slot, which provides an interlocking feature. It is cemented with special patch cement.
For further information circle No. 1274 on literature request card, p. 48-B.

Low-Temperature Chamber

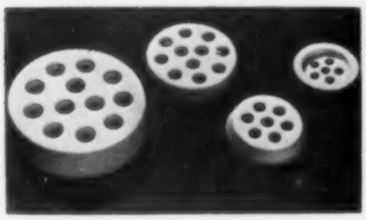
Tenney Engineering has announced the construction of an extremely low-temperature environmental test chamber for an aircraft manufacturer. This unit has a special, hinged 20 by 20 in. access door located beside the window in one 8 by 10 ft. side. This door may be opened to allow manual



instrument changes and adjustments without completely dissipating the environmental temperature conditions. A 40 hp. drive shaft penetrating one side of the chamber is capable of producing from 750 to 4500 r.p.m. All automatic programming instrumentation allows for complete pre-setting and pre-selection. This test chamber has a temperature range of —100 to +220° F.
For further information circle No. 1275 on literature request card, p. 48-B.

Strainer Cores

Star Porcelain Co. has announced the availability of a new line of Strainrite refractory strainer cores. These strainer cores keep slag and sand core inclusions out of castings, and permit closer control of the molten



metal. They withstand 3000° F. temperatures without spalling or disintegrating. They are available in sizes up to 4¼ in. diameter. Samples are available.
For further information circle No. 1276 on literature request card, p. 48-B.

APPLICATION and EQUIPMENT new literature

1278. Abrasion Tester
Bulletins on durable precision instrument for evaluating the resistance of surfaces to rubbing abrasion. *Taber Instrument*

1279. Abrasive Wheels
Operating suggestions and recommended wheels for finishing stainless. *Manhattan Rubber Div.*

1280. Alloy Castings
22-page bulletin 2041 on heat and corrosion resistant castings. *Blaw-Knox*

1281. Alloy Selection
Chart to select alloy for given corrosive problem. 350 corrosives included. *Cooper Alloy*

1282. Alloy Steel
68-page "Aircraft Steels" includes revised military specifications. Also stock list. *Ryerson*

1283. Aluminum
12-page booklet on extruded shapes, tube and pipe, coiled sheet, forgings and properties of aluminum alloys. *Revere*

1284. Aluminum Bronze
8-page booklet on aluminum bronze bearing material which is forgeable, corrosion resistant, lightweight. *Mueller*

1285. Aluminum Bronze
20-page booklet on high-aluminum, high-iron bronze alloys gives chemistry, physical properties, description and uses. *Ampco Metal, Inc.*

1286. Aluminum Extrusions
Folder lists alloys used, finishes, trade phraseology. *General Extrusions, Inc.*

1287. Aluminum Die Castings
Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

1288. Aluminum Finish
Bulletin on new invisible finish for aluminum describes Alodine No. 1000 and includes flow sheet for immersion process. *American Chemical Paint*

1289. Aluminum Finishing
New bulletin on process for applying conversion coating to aluminum and zinc. *Oakite*

1290. Aluminum Heat Treating
8-page Bulletin 5912 on solution heat treating, annealing, stabilizing and aging of aluminum. *General Electric*

1291. Aluminum Strip
20-page booklet on how it is made, sizes and weights of coils. Technical data on aluminum alloys used. *Scovill*

1292. Aluminum Tube
New 4-page folder on aluminum for furniture industry gives mechanical and chemical properties. *United Wire & Supply Corp.*

1293. Annealing
Article on annealing galvanized wire at Western Electric Co. in Metal Minutes for June 1956. *Sunbeam Corp.*

1294. Atmosphere Furnace
12-page bulletin 1054 on electric furnaces with atmosphere control for hardening high speed steel. *Sentry*

1295. Atmosphere Furnace
Information on mechanized batch-type atmosphere furnaces for gas cyaniding, gas carburizing, clean hardening or carbon restoration. *Dow Furnace*

1296. Atmosphere Furnace
Bulletin on controlled atmosphere furnace. *Industrial Heating Equipment*

1297. Atmosphere Furnace
12-page bulletin on controlled atmosphere reciprocating hearth furnace for continuous hardening, light case carburizing, Ni-Carb ammonia-gas carburizing and other heat treating processes. *American Gas Furnace*

1298. Atmosphere Furnaces
Catalog on reciprocating hearth furnaces shows various designs and explains operation. *American Gas Furnace*

1299. Atmospheres
Bulletin on generator for producing pure nitrogen with a controllable hydrogen content. *Baker & Co.*

1300. Atmospheres
12-page bulletin on use of protective atmospheres to prevent deterioration of metals during various heat treating processes. *General Electric*

1301. Batch-Type Furnaces
Bulletin SC-174 on furnaces in the operating range of 1400 to 1750° F. for various heat treating processes. Suction radiant tube fired units and mechanized systems. *Surface Combustion*

1302. Beryllium Copper
12-page Bulletin 6 on advantages of beryllium copper and suggestions for ordering, including alloys, condition and temper, tolerances. *Penn Precision Products*

1303. Black Oxide Coatings
8-page booklet on black oxide coatings for steel, stainless steel and copper alloys. *Du-Lite*

1304. Blast Cleaning
Complete information on Malleabrasive for cleaning and finishing. *Globe Steel Abrasive*

1305. Boiler Refractories
20-page bulletin on boiler refractories discusses basic requirements of refractories, what causes refractories to fail, various kinds of insulating firebrick. *Refractories Div., Babcock & Wilcox*

1306. Bonding Plastics
New literature on new method of bonding Teflon and Rulon by surface treatments. *Dixon Corp.*

1307. Brazing
Bulletin 5889 on furnace and induction brazing installations and methods. *General Electric*

1308. Brazing
4-page reprint on use of salt baths in production and small scale brazing of simple and complex assemblies. *Ajax Electric*

1309. Brazing Aluminum
12-page bulletin, ADR 45, on how to torch braze aluminum and strength of joints so brazed. *Air Reduction Sales*

1310. Brush Finishing
4-page bulletin on precision brush finishing of cylindrical parts with centerless grinders. *Osborn Mfg.*

1311. Calibrating Machine
Bulletin 115 on calibrating system for accurate measurement of mechanical forces. *Morehouse Machine*

1277. Pearlitic Malleable
This new 24-page booklet provides charts, micrographs and text to describe the strength and machinability of pearlitic malleable iron in highly stressed parts. Metallurgical characteristics of pearlitic malleable iron,

its specifications, mechanical properties, hardenability, applications, machining power requirements, tool life, surface finishes and elevated temperatures properties are considered. *Albion Malleable Iron Co.*

1312. Carbon Control
Technical report on instrument for control of carbon potential of furnace atmospheres. *Lindberg Eng'g*

1313. Carbon Refractories
New catalog section on carbon products for cupola furnaces gives physical properties of carbon refractories and describes applications. *National Carbon*

1314. Carbonitriding
28-page booklet on nature of process, furnaces, atmospheres, parts carbonitrided and properties. *Armour Ammonia*

1315. Carburizing Salts
Folder on salts for liquid carburizing. *Swift Industrial Chemical*

1316. Carburizing Steels
12-page reprint on making gears of new carburizing steels. *Climax Molybdenum*

1317. Centerless Grinding
28-page reprint gives advantages, applications and economics, fundamentals and methods, machines and attachments, wheels and wheel selection chart. *Keystone Abrasive Wheel Co.*

1318. Chain Curtains
12-page booklet on chain furnace curtains tells how and where they can be used. *E. J. Codd*

1319. Chromate Finishing
File on chromate conversion coatings for prevention of corrosion and paint-base treatment of nonferrous metals. *Allied Research Products*

1320. Chromium Plating
Bulletin CFC-1 on advantages of crack-free chromium plating process. *United Chromium Div., Metal & Thermit Corp.*

1321. Chromium Stainless
12-page book on fabrication and use of Type 430 stainless steel. *Sharon Steel*

1322. Chromizing
4-page folder describes how to make iron powder components resistant to rust and wear. *Chromalloy Corp.*

1323. Cleaner
Folder gives data on metal cleaners for use with water in still-tank or spray-washing equipment. *Solventol*

1324. Cleaning
12-page Technical Letter No. 11 gives recommended surface preparation of steel for red lead paints. *Lead Industries Assoc.*

1325. Coatings
New bulletin gives uses of various conversion coatings for zinc and cadmium. *Chemical Corp.*

1326. Coatings
Bulletin on coatings of tungsten carbide. Preparing parts for fusecoating. Allowances for distortion. *Fusion Metal Coating Co.*

1327. Coatings
4-page bulletin on how pure metallized zinc or aluminum coatings prevent corrosion. Typical applications. *Metallizing Engineering Co.*

1328. Combustion Control
20-page booklet on combustion of various fuels and portable instrument to measure content of oxygen and combustibles. *Cities Service Oil*

1329. Compressors
12-page bulletin 126-A on application of turbo compressors to oil and gas-fired equipment used in heat treating, agitation, cooling, drying. Performance curves, capacities. *Spencer Turbine*

1330. Continuous Mill Drives
10-page booklet describes new mill drive incorporating a differential gear with variable speed hydraulic unit for each stand with all stands driven by a common line shaft from the main motor. *Mannesmann-Meer Engineering*

1331. Controlled Atmospheres
Bulletin 753 on generator for atmospheres for hardening, brazing, sintering and annealing carbon steels. *Hevi Duty*

1332. Controllers
56-page bulletin on new series 500W pneumatic controller. Control principles and control modes available. *Bristol Co.*

1333. Controllers
80-page catalog 8305 on nonindicating electric, electronic and pneumatic controllers for temperature, pressure and humidity. *Minneapolis-Honeywell*

1334. Copper Alloys
40-page book on eleven copper alloys. Properties, cleaning, annealing. *Seymour*

1335. Copper Alloys
64-page book on free-cutting brass, copper and bronze. *Chase Brass*

1336. Copper Plating
Cu-3 tells of advantages of pyrophosphate copper plating process. *Metal & Thermit*

1337. Corrosion Resistant Alloy
Data sheet compares corrosion properties of Elgiloy and stainless steel. *Elgin National Watch Co.*

1338. Creep Testers
Data file lists 8 models, gives salient features, and illustrates them and uses. *Arcweld Mfg.*

1339. Creep Testing
Bulletin 4208 on five types of creep testing machines for standard sized metal specimens. *Baldwin-Lima-Hamilton*

1340. Decarburization
8-page booklet on effects of decarburization on tool steels tells what it is and what can be done about it. *Carpenter Steel*

1341. Definitions
36-page glossary of over 150 terms on cast iron. *International Nickel*

1342. Degreasing
34-page booklet on vapor degreasing. Design, installation, operation and maintenance of equipment. *Circo Equipment*

1343. Descaling
Bulletin on system of descaling stainless, alloy steels and titanium after heat treating. *Kolene Corp.*

1344. Descaling Process
8-page bulletin on sodium hydride descaling process for ferrous and nonferrous metals. *DuPont*

1345. Descaling Stainless Steel
Bulletin 25 on descaling stainless steel and other metals in molten salt. *Hooker Electrochemical*

1346. Die Casting
Illustrated catalog on complete line of die casting machines. *Kux Machine*

1347. Drawing Titanium
6-page reprint on techniques for drawing and other forming methods. Experience with severe forming operations. *Brooks and Perkins*

1348. Electric Furnace
Bulletin on box-type, pre-heat and hardening furnace with automatic atmosphere contamination control. *Pacific Scientific*

1349. Electric Furnaces
Catalog of electric furnaces and ovens for hardening, tempering, annealing, drawing, drying, baking, enameling. *Cooley Electric Mfg.*

1350. Electric Furnaces
Brochure on electric heat treating, melting, metallurgical tube, research and sintering furnaces. *Pereny Equipment*

1351. Electric Melting
Bulletin 527 on compact arc furnace. Melt time and power consumption for four alloys. *Detroit Electric Furnace*

1352. Electron Tubes
8-page directory of interchangeability of Machlett tubes with others. *Machlett Laboratories*

1353. Electroplating
"Industrial Precision Electroplating" tells of facilities for metal finishing, growth and advancements of metal finishing, requirements of specific industries. *Summit Finishing Co.*

1354. Electropolisher
Bulletin on theory and practice of electrolytic polishing and metallurgical samples. Description of electropolisher. *Buehler*

1355. Extrusion
Folder describes the hot extrusion process and gives its history. *Jones & Laughlin*

1356. Fabrication
12-page booklet tells of facilities for various types of fabrication. Capacity limits, presses. *Plume & Atwood Mfg. Co.*

1357. Fatigue of Magnesium
18-page paper, "Plastic Flow and Work Hardening Phenomena in Magnesium Alloys During Fixed-Deflection Fatigue Tests". *Dow Chemical*

1358. Ferro-Alloys and Metals
104-page book gives data on more than 250 different alloys and metals produced by the company. *Electro Metallurgical*

1359. Finishing
16-page bulletin 51 on handling, metal cleaning, precision finishing and baking equipment. *Despatch Oven*

1360. Flame Hardening
20-page booklet on precision flame hardening machine with electronic control. Details of operation and applications. *Cincinnati Milling Machine*

1361. Flame Plating
16-page booklet lists advantages, properties, specifications of flame-plated tungsten carbide coating. *Linde*

1362. Flaw Detection
4-page folder on how to perform dye penetrant inspection. Precleaning, applying penetrant, removing excess penetrant, applying developer and interpreting results. *Turco Products*

1363. Flaw Location
12-page booklet on dye penetrant inspection method. Suggestions on how to perform inspection by this method. *Turco Products, Inc.*

1364. Flow Meters
Bulletin 201 on flow meter for gas used in heat treating. *Waukee Eng'g*

1365. Forgings
New 6-page booklet on closed die forgings and their advantages. *Drop Forging Assoc.*

1366. Forgings
94-page book on die blocks and heavy-duty forgings. 20 pages of tables. *A. Finkl & Sons*

1367. Forgings
New catalog on forging and casting products contains information on air hardening, oil hardening and other cast-to-shape tool steel specialties. *Allegheny Ludlum*

1368. Forgings
8-page bulletin on closed die forgings gives forging sizes, forging stock and shapes. *Indiana Forge and Machine*

1369. Formed Shapes
26-page catalog No. 1555 contains drawings and dimensions of more than 100 shapes. *Roll Formed Products Co.*

1370. Furnace Belts
42-page booklet on alloy steel belts for continuous high-temperature furnaces. Belt selection guide. *Wickwire Spencer Steel Div.*

1371. Furnaces
Bulletin 435 on furnaces for tool room, experimental or small batch production. Gas, oil, electric. Muffle or direct heated. *W. S. Rockwell*

1372. Furnaces
New 4-page folder on electric or gas

radivection furnace, with combined radiant heat and forces convection. *A. F. Holden*

1373. Furnaces
High-temperature furnaces for temperatures up to 2000° F. are described in bulletin. *Carl-Mayer Corp.*

1374. Furnaces
Folder describes complete set up for heat treatment of small tools, including draw furnace, quench tank and high temperature furnace. *Waltz Furnace*

1375. Furnaces
New catalog on standard and special furnaces and ovens to 3000° F. *L & L Mfg.*

1376. Furnaces
Bulletin on electric heat treating furnaces describes five series and accessories. *Lucifer Furnaces*

1377. Furnaces
Complete information on custom built furnaces for all types of work. *Martin Mfg.*

1378. Furnaces
Series of bulletins on laboratory facilities, atmosphere equipment, pusher-type furnaces, tool hardening or preheat furnaces. *C. I. Hayes, Inc.*

1379. Furnaces, Heat Treating
12-page bulletin on conveyor furnace, radiant tube gas heated, oil or electrically heated. *Electric Furnace Co.*

1380. Fused Silica
Folder on fused silica which is resistant to high temperatures, thermal shock, acids and has high electrical insulating value. *Amersil*

1381. Gas Analysis
Bulletin 11-11 on portable and continuous instruments for detection and measurement of combustible gases and vapors, oxygen, toxic gases and gas proportioning and control. *Davis Instrument Div.*

1382. Gas Analysis
Bulletin 482 on gas chromatograph for analysis of gases and low-boiling liquids. How it works. *Harshaw Scientific*

1383. Gas Analysis
Data sheet on instruments used to record gas and vapor concentrations during combustible gas analysis. *Minneapolis-Honeywell*

1384. Gas Analysis
New folder on equipment for thermal conductivity gas analysis. Method of measurement and applications. *Leeds & Northrup*

1385. Gas Carburizing
Basic principles of quality gas carburizing in Heat Treat Review, Vol. 7, No. 2. *Surface Combustion Corp.*

1386. Gas Generator
Bulletin 753R on endothermic generator gives construction, principles of operation, special features. *Hevi-Duty*

1387. Gold Plating
Folder on salts for bright gold plating. Equipment needed. *Sel-Rex*

1388. Graphite Electrodes
Vest-pocket notebook containing 90 pages of information on electric furnace electrodes and other carbon products. *Great Lakes Carbon Corp.*

1389. Grinding Wheels
Folder on grinding wheel especially adapted for use in steel mills shows structure and gives advantages. *Sterling Grinding Wheel Co.*

1390. Hardness Tester
Bulletin on Wolpert-Gries Micro-Reflex hardness tester for loads from 10 to 3000 g. *Gries Industries, Inc.*

1391. Hardness Tester
Data on hardness testing scleroscope with equivalent Brinell and Rockwell C numbers. *Shore Instrument*

1392. Hardness Tester
Bulletin on how to test large gears with portable Brinell tester. *King Tester*

1393. Hardness Tester
Bulletin on Impressor portable hardness tester for aluminum, aluminum alloys and soft metals. *Barber-Colman*

1394. Hardness Testers
Folder on portable hardness testers for testing of various sizes, shapes and types of metal. *Newage International*

1395. Hardness Testers
20-page bulletin on models, applications and how to use superficial hardness testers. *Wilson Mechanical Instrument*

1396. Hardness Testers
20-page book on hardness testing by Rockwell method. *Clark Instrument*

1397. Hardness Testing
8-page catalog B-953 on principles and standards of Brinell hardness testing, and types of machines. *Steel City Testing Machines*

1398. Heat Treating
16-page book on heat treating and pickling of stainless steels. Annealing, hardening and tempering temperatures and resulting properties. *Crucible Steel*

1399. Heat Treating
Bulletin 14-T on ovens for heat treatment of aluminum and other low-temperature processing. *Young Bros.*

1400. Heat Treating
Catalog of complete line of heat treating furnaces and atmosphere generators, electric and fuel fired. *Sargeant and Wilbur*

1401. Heat Treating
New edition of 73-page vest pocket data book on heat treating. Charts, tables, diagrams and factual data. *Sunbeam Corp.*

1402. Heat Treating
Bulletin describes baskets, crates, trays, furnace parts for heat treating. *Stanwood*

1403. Heat Treating
Reference sheet gives procedures for preparing parts for heat treating. *Metal Treating Institute*

1404. Heat Treating
8-page article on heat treatments for ductile iron. Process for developing tensile strength from 60,000 to 150,000 psi. and elongation to 25%. *International Nickel Co.*

1405. Heat Treating Ammonia
24-page "Guide for Use of Anhydrous Ammonia" describes heat treating and other metallurgical uses. *Nitrogen Div.*

1406. Heat Treating Belts
Catalog of conveyor belts and data for their design, application and selection. *Ashworth Bros.*

1407. Heat Treating Fixtures
12-page bulletin on wire mesh baskets for heat treating and plating. *Wiretex*

1408. Heat Treating Fixtures
24-page catalog on heat and corrosion-resistant equipment for heat treating and chemical processing. 30 classifications of equipment. *Pressed Steel*

1409. Heat Treating Fixtures
24-page catalog B-8 on muffles, retorts, baskets, other fixtures for heat treating in gas or salt baths. *Rolock*

1410. Heat Treating Fixtures
Folder on carburizing boxes, trays, heat treat fixtures and baskets. *Misco*

1411. Heat Treating Furnaces
32-page catalog on high-speed gas furnaces for heat treating carbon and alloy steels; also pot furnaces for salt and lead hardening. *Charles A. Hones*

1412. Heat Treating Furnaces
12-page booklet on various heat treating furnaces contains chronology of advances in heat treating furnaces. *Holcroft*

1413. Heat Treating Pots
Bulletin 110 gives data on sizes and shapes of cast nickel-chromium solution pots. *Fahralloy*

1414. Heating Elements
24-page booklet on elements for electric furnaces and kilns includes technical data, uses, physical and electrical specifications. *Norton*

1415. High-Alloy Assemblies
4-page folder on various types of process equipment of heat and corrosion resistant alloys. *General Alloys Co.*

1416. High Alloy Castings
16-page bulletin No. 3354-G gives engineering data concerning castings used for resisting high temperatures, corrosion and abrasion. *Duraloy Co.*

1417. High-Strength Steel
48-page book on T-1 steel, its properties and applications. *U.S. Steel*

1418. High-Strength Steel
26-page booklet on properties, uses, applications of high-tensile low-alloy steel. *Jones & Laughlin*

1419. High-Temperature Alloys
Booklet "Keep Operating Costs Down When Temperatures Go Up." *International Nickel*

1420. High-Temperature Belts
Bulletin T-241 on belts of high-temperature alloy for heat treat furnaces. *Electro-Alloys*

1421. High-Vacuum Furnaces
12-page brochure No. 790 on vacuum furnaces for melting and casting titanium, zirconium, germanium, copper, iron and steel. Also furnaces for annealing, hardening, brazing. *F. J. Stokes*

1422. High-Strength Steel
66-page catalog on Mayari*R steel. Applications which take advantage of its wear and corrosion resistance. *Bethlehem Steel*

1423. Impact Testing
Bulletin on machine for Izod, Charpy and tension testing. *Riehle*

1424. Induction Heat Control
2-page data sheet on detector and controller and how it is used for continuous, batch and selective induction heating processes. *Leeds & Northrup*

1425. Induction Heating
8-page bulletin on forging with induction heat includes case histories, benefits to the forging industry. *General Electric*

1426. Induction Heating
New bulletin on remote heating station for motor generator induction heating equipment. *Lindberg Engineering Co.*

1427. Induction Heating
Folder on high-frequency induction heating for heat treatment, joining and hot forming. Charts on current penetration in steel. *Magnethermic*

1428. Induction Heating
12-page bulletin B-6519 on motor generator sets, r.f. generators, work stations, handling equipment. *Westinghouse Electric*

1429. Induction Heating
60-page catalog tells of reduced costs

and increased speed of production on hardening, brazing, annealing, forging or melting jobs. *Ohio Crankshaft*

1430. Induction Melting
8-page reprint R-50 on recent development of coreless line frequency induction melting furnace in European foundries. *Ajax Engineering*

1431. Industrial Heating
New booklet on process heating operations for light metals. *Michigan Oven Co.*

1432. Ingot Stripper
Folder on operation and functions of portable hydraulic ingot stripper. Diagrams of two standard sizes. *Pittsburgh Engineering & Machine Co.*

1433. Inoculant
New 96-page booklet on SMZ alloy, an inoculant for cast iron. Metallurgical aspects of inoculation. How to inoculate irons. *Electro Metallurgical Co.*

1434. Inspection
Descriptive information and instructions for new inspection process to detect surface flaws on all ferrous and nonferrous metals. *Zaco Laboratories*

1435. Instruments
32-page catalog of instruments for analysis, control and data processing. *Consolidated Electrodynamics Corp.*

1436. Insulation
40-page industrial products catalog on insulations, refractory products and others. *Johns-Manville*

1437. Investment Casting
27-page reprint tells of development and applications of Shaw process of precision casting. *Shaw Development Corp.*

1438. Investment Casting
12-page brochure on the process, shapes which may be cast, tolerances, assembly savings. *Investment Casting Co.*

1439. Laboratory Equipment
Data sheets on three models of Projecta analytical projection balances and balance table. *C. A. Brinkmann & Co.*

1440. Laboratory Equipment
20-page catalog of apparatus for chromatography and electrophoresis including balances, colorimeter, densitometer, spectrophotometers. *Harshaw Scientific*

1441. Laboratory Furnaces
Folder describes and illustrates tubular furnace for use in tensile testing, and control panels. *Marshall Products*

1442. Leaded Steel
8-page booklet on production of lead treated steels, their advantages and case histories of their use. *Copperweld Steel*

1443. Lubricant
Bulletin 425 on colloidal dispersions for use in metal casting. Best formulas for achieving high lubricity and wetting action. *Acheson Colloids*

1444. Lubricant
Bulletin 103A on fringe area lubrication with molybdenum disulfide lubricants for extreme bearing pressures and all temperatures. *Alpha Corp.*

1445. Lubricants
8-page booklet on colloidal greases, forging compounds, hydraulic concentrate and others. *Grafo Colloids*

1446. Machining Copper
12-page bulletin on machining properties, practices, feeds, speeds, tool design. *Ampco*

1447. Magnesium
42-page booklet on wrought forms of magnesium. Includes 31 tables. *White Metal Rolling & Stamping*

1448. Magnesium Dust
8-page brochure on methods of collecting and controlling magnesium alloy dust and fumes. *Peters-Dalton*

1449. Malleable Castings
Continuing series of information bulletins covering latest techniques and practices in modern malleable casting. *Malleable Founders' Society*

1450. Marking Machines
26-page catalog of marking machines and tools. Production roll marking and bar stock speed markers described. *Noble & Westbrook Mfg. Co.*

1451. Master Alloys
24-page pocket bulletin on high alloy materials also includes metric equivalents tables, element melting points, temperature conversion tables. *Alter Co.*

1452. Melting Furnaces
28-page catalog on Heroult electric melting furnaces. Types, sizes, capacities, ratings. *American Bridge*

1453. Melting Aluminum
Bulletin 310 on furnaces for melting aluminum. *Lindberg Eng'g*

1454. Metal Analysis
Brochure on Quantometer, which furnishes pen-and-ink records of quantitative spectrochemical analyses with extra copies. *Applied Research Labs.*

1455. Metal Coating
Data Sheet 5.5-1 on instruments and controls to automatically maintain boiling point and concentration of solution in coating process. *Minneapolis-Honeywell*

1456. Metal Cutting
64-page catalog No. 29 gives prices and describes complete line of rotary files, burrs, metalworking saws and other products. *Martindale Electric*

1457. Metallograph
20-page bulletin E-232 on Balphot metallograph with bright field, dark field, polarized light, phase contrast. *Bausch & Lomb*

1458. Microhardness Tester
Bulletin describes the Kentron microhardness tester. *Torsion Balance Co.*

1459. Microscope
New brochure SB56 on cycloptic stereoscopic microscope. *American Optical*

1460. Microscopes
Catalog on metallograph and several models of microscopes. *United Scientific*

1461. Molybdenum
24-page booklet gives physical and chemical property data on molybdenum powders, wire, alloys. *Sylvania Electric*

1462. Molybdenum
72-page book gives data on unalloyed molybdenum and four arc-cast alloys. Several pages of references. *Climax Molybdenum*

1463. Monel
Booklet on engineering properties of cast Monel. *International Nickel Co.*

1464. Motion Pictures
12-page booklet gives five case histories showing how movies solved engineering problems. *Professional Goods Div., Eastman Kodak Co.*

1465. Nickel Alloys
38-page handbook on wire, rod, strip of Monel, Inconel, nickel and nickel clad copper. *Alloy Metal Wire Co.*

1466. Nitriding
Data on process for nitriding stainless steel. *Standard Steel Treating*

1467. Nondestructive Testing
8-page bulletin on equipment for non-

destructive testing of bars, rods, tubing. *Magnetic Analysis*

1468. Nonflammable Rust Preventive
Bulletin on rust preventive compound which is water soluble, nontoxic and nonflammable. *Production Specialties*

1469. Oil Quenching
8-page brochure tells in detail how carbon steel often can replace alloy steel when additive is used in the quenching oil. *Aldridge Industrial Oils*

1470. Openhearths
Brochure on modern openhearth design and construction. *Loftus*

1471. Optical Pyrometer
Catalog No. 85 on optical pyrometer which is direct reading. Method of operation, maintenance. *Pyrometer Instrument*

1472. Ovens
4-page bulletin on mechanical convection ovens for laboratory, pilot plant and production. *Blue M Electric*

1473. Oxygen
Folder on new liquid oxygen cylinder with 3000 cu. ft. capacity. *Linde*

1474. Patterned Metal
6-page booklet on Roll-Bond, patterned metal for heat and cold transfer applications. How it is made and uses. *Western Brass Mills Div., Olin Mathieson Chemical*

1475. pH Measurement
New bulletin on instrumentation for pH measurement and automatic control. *Bristol*

1476. Phosphate Coating
12-page "Phosphate Coating Chemicals and Processes" gives data on paint bonding, rust proofing, protecting friction surfaces, improving drawing and extrusion. *American Chemical Paint*

1477. Pickling Baskets
Data on baskets for degreasing, pickling, anodizing and plating. *Jelliff*

1478. Pickling Baskets
12-page bulletin on mechanical picklers, crates, baskets, chain and accessories. *Youngstown Welding & Eng'g*

1479. Pipe and Tubing
68-page book on pipe and tube making, answering many pertinent questions on tube mill operation and production. Engineering data and specifications. *Yoder*

1480. Plating
New 8-page brochure on test equipment for plating baths. Controls, anodes, cathodes, agitators, rectifiers described. *R. O. Hull & Co.*

1481. Portable Recorder
Bulletin 60-100 on instrument for recording any measurement that can be converted to a change in resistance of d.c. millivoltage. *Thermo Electric*

1482. Powder Press
Dorst automatic press for powdered metal is described in bulletin. Pressure ram stroke and other specifications. *Arnhold Ceramics*

1483. Powdered Metals
Bulletin 800-B on pre-alloyed iron powders with varied chromium-nickel contents. *Metal Hydrides*

1484. Precision Casting
Fact Sheet tells what Shaw process is, what alloys can be used, equipment, tolerances, and shows examples of investment castings. *Shaw Process Development*

1485. Precision Casting
12-page book on alloy selection and design for investment casting. *Arwood Precision Casting*

1486. Precision Casting
8-page bulletin on investment castings of various ferrous and nonferrous alloys. *Engineered Precision Casting*

1487. Precision Castings
20-page book on alloys used, specification ranges, advantages and castings made by precision casting. *Haynes Stellite*

1488. Protecting Tubes
New bulletin 1000-56 on ceramic protecting tubes lists sizes and materials. *Claud S. Gordon*

1489. Pyrometer
Specification S-939-4 on small target radiamatic pyrometer for temperatures from 1700 to 7000° F. *Minneapolis-Honeywell*

1490. Pyrometers
12-page Bulletin 713 on indicating and controlling pyrometers. Functional diagrams of installations. *General Electric*

1491. Quenching
Bulletin No. 11 on quenching oil also discusses advantages of quench agitation. *Sun Oil Co.*

1492. Quenching Oil
Book on mechanism of quenching, properties of quenching mediums, cooling curves. *Gulf Oil*

(*Continued on page 48-A*)

(Continued from page 47)

1493. Radiation Detection
Data bulletins on cells give their advantages, describe two models and explain engineering principles. *Servo Corp.*

1494. Radiation Gages
New 12-page booklet on continuous noncontacting gages describes advantages, accessory equipment, engineering principles and gives engineering data. *Pratt & Whitney*

1495. Radiography
18-page bulletin on materials and accessories for radiography. Density curves for four types of films. *X-Ray Div., Eastman Kodak*

1496. Rare Earths
Folder on high-purity rare earths gives their properties and properties of oxides. Uses. *St. Eloi Corp.*

1497. Refractory Cement
New 8-page folder on heavy duty brick bonding and patching mortar. How it is used. Service reports. *Refractory & Insulation Corp.*

1498. Refractory Coating
Data on aluminum oxide and silicon carbide coating which may be sprayed on. *Norton Co.*

1499. Refractory Metals
24-page booklet on tungsten, molybdenum, tantalum, their properties and uses. *Fansteel Metallurgical Corp.*

1500. Resistance Welding
56-page catalog of resistance welding products, accessories and materials. Selection of alloys and electrode materials. *Weldaloy Products Co.*

1501. Rhodium Plating
Data on properties, thicknesses required, costs, operation, applications. *Technic*

1502. Rust Prevention
72-page book on cleaning, preservation, and packaging of metals. Causes of corrosion. *E. F. Houghton*

1503. Rust Removal
Booklet on stripper for removal of rust, paint, phosphate coatings and other soils. *Metasurf Corp.*

1504. Salt Bath Descaling
12-page bulletin B-40 describes continous and batch descaling lines for removing oxide from steel, bronze, copper, stainless and titanium. *Drever*

1505. Salt Bath Furnaces
Data on salt bath furnaces for batch and conveyorized work. *Upton*

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1506. Salt Baths
32-page bulletin on salts for tempering, annealing, neutral hardening, martempering and carburizing. Heat treating data. *E. F. Houghton*

1507. Salt Baths
Reprints 161 and 162 on new advances in hot salt quenching and salt bath quenching of gears. *Ajax Electric*

1508. Saw Blades
Selector for hand or power blades tells which blade to use for various alloys and shapes. *Henry Disston*

1509. Selective Strippers
Bulletin on materials for selective stripping of one metal from another—electroplated metals, solder or brazing excess. *Enthone*

1510. Sheet Feeder
New 6-page brochure on 150-sheet per minute metal sheet feeder. Operating features and specifications. *Dexter Folder*

1511. Shot and Grit
Handy calculator has size data for SAE grades of shot and grit. *Pangborn*

1512. Silver Brazing
48-page manual on all aspects of silver brazing applications and problems. *American Platinum Works*

1513. Sodium
40-page booklet on handling metallic sodium gives typical sodium-using processes, equipment installation, recommendations for pumping and instrumentation. *U.S. Industrial Chemicals*

1514. Soldering
New 2-page bulletin on silver bearing soft solders. Alloy selection, applications and available alloys. *Alpha Metals*

1515. Soldering Fluxes
Discussion in "Federated Metals Digest", Vol. 3, No. 1, of various types and their advantages. *Federated Metals*

1516. Sonic Thickness Tester
Measurement of wall thickness from one side by sonic method. *Branson*

1517. Specifications Index
28-page cross index lists copper alloy specifications of nine different Government agencies. *American Brass*

1518. Spectrographic Sources
4-page bulletin 35A on spectrographic source unit gives data on three units available. *Baird Assoc.*

1519. Spectroscopes
New catalog on diffraction, prism, reversion and ultraviolet spectroscopes and accessories. *Ealing Corp.*

1520. Spot Welding
Bulletin 339 on spot welder with predetermined electronic control. Circuits employed. *Sciaky Bros.*

1521. Stainless Castings
20-page booklet shows how they are made, property and size data, typical applications. *Crucible Steel*

1522. Stainless Castings
8-page bulletin gives recommendation charts for type of stainless to use in various corrosive solutions, under various conditions. *Waukesha Foundry*

1523. Stainless Fastenings
20-page catalog of stainless steel cap screws, nuts, washers, machine screws, sheet metal screws, set screws, pipe fittings and specialties. *Star Stainless Screw*

1524. Stainless Steels
10-page booklet contains charts, graphs, data on cold rolled mechanical properties, elevated temperature properties, physical properties and corrosion resistance of chromium-nickel-manganese steels. *Allegheny Ludlum*

1525. Steel 52100
Data sheet on high-purity 52100 steel, made by vacuum melting. *Vacuum Metals*

1526. Steelmaking
Carbon and Graphite News for June 1956 tells how specialty steels are made in an electric arc furnace in 99 hr. from order to finished product. *National Carbon*

1527. Stereomicroscopes
38-page catalog D-15 shows value of three-dimensional microscopes for industrial assembly lines and research laboratories. *Bausch & Lomb Optical*

1528. Surface Temperature
Bulletin No. 4257 on Pyrocon, surface temperature instrument. *Illinois Testing Laboratories*

1529. Swaging Machines
16-page catalog on complete line of swaging equipment contains data on rotary swaging process and its applications. *Fenn Mfg. Co.*

1530. Temperature Control
New 8-page bulletin on temperature control systems contains selection guide, terminology, types of control systems. *Wheelco Instrument Div.*

1531. Temperature Control
Facts folder on Magamp link units for proportional temperature control systems. *Westinghouse Electric*

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Specification Sheet S1010-1 on electronic temperature controller gives specifications and uses. *Minneapolis-Honeywell*

1533. Test Specimens
Data on machine for cutting test specimens to ASTM specifications. *Sieburg Industries*

1534. Testing Instruments
16-page bulletin on portable recorders, voltmeters and ammeters, surface roughness scales and other electric testers. *General Electric*

1535. Testing Machines
8-page folder on Amsler machines for tests in tension, compression, torsion, shear, fatigue, bending and ductility. Bulletins on wear testing and testing of miniature samples. *Buehler*

1536. Testing Machines
12-page catalog on ten testers including hardness, ductility, tensile, compression and transverse strength. *Detroit Testing Machine*

1537. Tin
New booklet describes mining of tin and its importance to American industry. *Malayan Tin Bureau*

1538. Titanium
8-page booklet on corrosion resistance of titanium. Table of ratings of titanium compared with stainless and aluminum in various mediums. *Mallory Sharon*

1539. Titanium Carbide
29-page pocket-sized book reviews methods of manufacture, properties, uses. Bibliography. *Titanium Alloy Mfg. Div.*

1540. Tool Steel
Wall chart showing more than 300 varieties of tool steel with trade name of manufacturers. *Vulcan Crucible Steel*

1541. Tool Steel Guide
70-page brochure includes information on 50 types of tool steels and cold finishing products. *Vanadium-Alloys Steel*

1542. Tool Steel Selector
Twist the dial of the 9-in. circular selector and read off the tool steel for your application. *Crucible Steel*

1543. Tool Steels
Bulletin on tool steels, hot work specialty steels, bar stock, billet, sand casting, drill rod, flat ground stock and tool bits. *Darwin & Milner, Inc.*

1544. Tubing
New 8-page catalog on carbon and alloy steel tubing of mechanical, pressure, airframe and aircraft mechanical quality. *Ohio Seamless Tube*

1545. Tubing
52-page "Handbook of Seamless Steel Tubing". 26 pages of data. *Timken*

1546. Tungsten
32-page book gives applications of tungsten, types of ore, mining. *Tungsten Institute*

1547. Ultrasonic Testing
6-page folder on immerscope diagrams instrument and tells how it may be used. *Curtiss-Wright Corp.*

1548. Ultrasonic Testing
Bulletin on testing equipment for measuring thickness, lack of bond, laminar-type defects. *Magnaflux*

1549. Vacuum Coating
Bulletin on principles, production steps, applications, equipment. *National Research*

1550. Vacuum Melting
8-page bulletin on production and testing equipment for vacuum melting. Advantage. *Utica Metals Div., Utica Drop Forge & Tool*

1551. Vacuum Metallizing
8-page catalog 551 on production and experimental-type metallizing units. *High Vacuum Equipment Corp.*

1552. Vacuum Metals
21-page report on vacuum melted metals discusses equipment, properties of metals and their applications. *Ajax Electrothermic Corp.*

1553. Vacuum Pumps
New 52-page catalog no. 425 on high vacuum pumps contains formulas and tabular data. *Kinney Mfg.*

1554. Vanadium in Steel
189-page book on properties of ferrous alloys containing vanadium and their applications. *Vanadium Corp.*

1555. Weight Slide
Folder on weight slide rule for figuring weights of forgings, stock, castings and others. How slide works. *Novotni Slide Rules*

1556. Welders
New 6-page bulletin on magnetic force welders. Advantages in welding difficult critical materials. *Precision Welder and Flexopress Corp.*

1557. Welding
7-page reprint on properties of weld deposits of nickel-molybdenum-vanadium steel. *International Nickel Co.*

1558. Welding
Data on welding positioners from 500 to 100,000 lb. capacity. *Harnischfeger*

1559. Welding
New bulletin 56L-171 on new, high-strength manganese bronze filler rod for oxyacetylene welding. *Ampco Metal*

1560. Welding
New 52-page manual on all methods of metal joining usual to the welding shop plus metal cutting without oxygen. Welding of various metals. *All-States Welding Alloys*

1561. Welding Electrode
Bulletin No. 5 on the development of an electrode for metal arc welding of wrought 35 Ni-15 Cr-1.25 Si alloy. *Rolled Alloys*

1562. Welding Electrodes
50-page book on electrodes of stainless, mild and high-tensile steels, cast iron, nonferrous alloys, low-hydrogen and hardfacing compositions. *Air Reduction*

1563. Welding Equipment
Folder on equipment for welding and cutting by the acetylene process. Regulators, torches and other equipment. *Dockson Corp.*

1564. Welding Equipment
Catalog on Cadweld process and arc-welding accessories. *Erico Products*

1565. Welding Magnesium
Article on inert-gas-shielded metal-arc welding of magnesium includes numerous illustrations and tables of data. *Dow Chemical*

1566. Wire
Bulletin A-1 on knitted stainless steel and nickel alloy wire shows applications. *Alloy Metal Wire Div., H. K. Porter Co.*

1567. Wire Mesh Belts
130-page manual on conveyor design, belt specifications, metallurgical data. *Cambridge Wire Cloth*

1568. X-Ray
12-page bulletin on gamma radiography tells how to select the source, equipment, techniques and fundamentals of gamma radiation. *Picker X-Ray*

1569. X-Ray Diffraction
New 4-page bulletin on X-ray diffraction for research, production control. Two units described. *General Electric, X-Ray Dept.*

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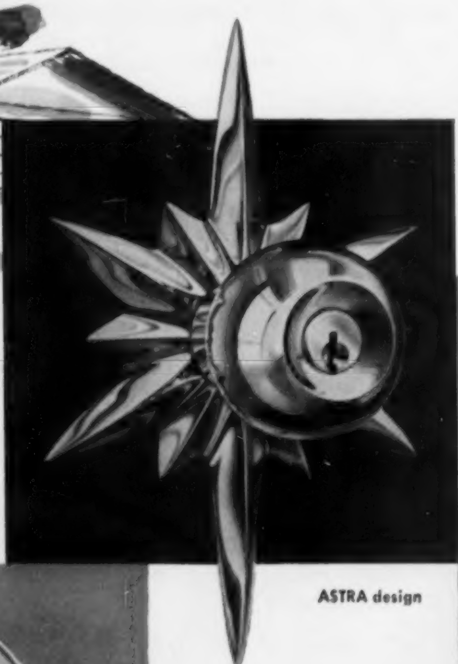

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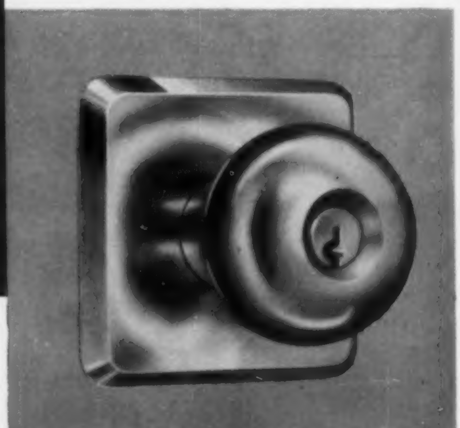

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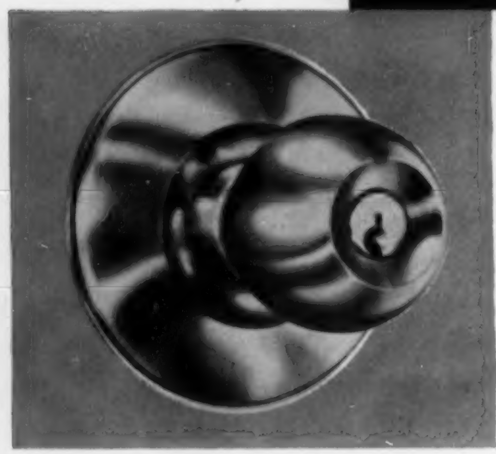

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METALS AND ALLOYS REVIEW

by FRANK M. LEVY
Vice-President and Director of Research

Last week one of our sales engineers was at the home office and we were talking about one of his customers in the East who manufactures milling machines which are being used for milling aircraft spars. We are supplying gibs, slide bars and wear strips to this company made of our "600" series bearing metal in rectangular rod form. The material formerly used was aluminum bronze* cast bars which they could only obtain in 36" lengths. Their engineering department estimates that costs have been reduced 50% on this component. Machining time has been reduced and impregnation of porous castings has been eliminated.

Our sales representative was curious about my experience with "600" in other applications such as this. Oddly enough, our own plant has been a pretty good proving ground. In our extrusion department, for example, we have gotten exceptionally good service from slides made of "600" and used on the die heads which are subject to pressure and extremely rough usage.

Bob Irwin of our forging department reports that the "600" strips he has used for lining the ways of our big forging presses have proved far superior to the bronzes which were original equipment. The bronze strips squashed out after protracted running. More important, the "600" strips last 10 times longer before replacement is necessary.

In our copper tube fabricating department we have a lot of automatic equipment for the production of formed tube shapes like tees and ells used in the plumbing industry. On one of the tube benders, there was no provision made for replacing worn forming slides. Our Maintenance Department reworked the machine using "600" strips as replaceable forming slide inserts. The bender is now a far more efficient machine. Because of the long life of "600", downtime on this machine has been practically eliminated.

While we were talking about these uses in our own plant, it brought to mind some other instances where the exceptionally good wearing properties of "600" have been established. A Cincinnati lathe manufacturer uses "600" in the form of counter sunk hex-headed screws on wearing strips used on lathe carriages. When the strip wears to the retaining screw the ways will not be scratched.

According to their own records, all other materials which they had tested proved unsatisfactory for the job. Another maker of precision lathes and milling machines found that after a year of exhaustive tests, the "600" metal that was used as nuts on compound slide screws outlasted competitive metals at an approximate ratio of 3 to 1 at an estimated saving of 30%.

Sliding surfaces on all kinds of machinery have different wear characteristics, as you have undoubtedly found. If you have any problems involving gibs, slide bars or wear strips that are proving troublesome, why not drop me a line or send a part print and we'll be glad to study it and make the proper recommendations.

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185

Germanium Zone Purification at IBM

Crystal Drawing

RELIES ON R-F INDUCTION HEATING WITH

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Germanium Zone Purification

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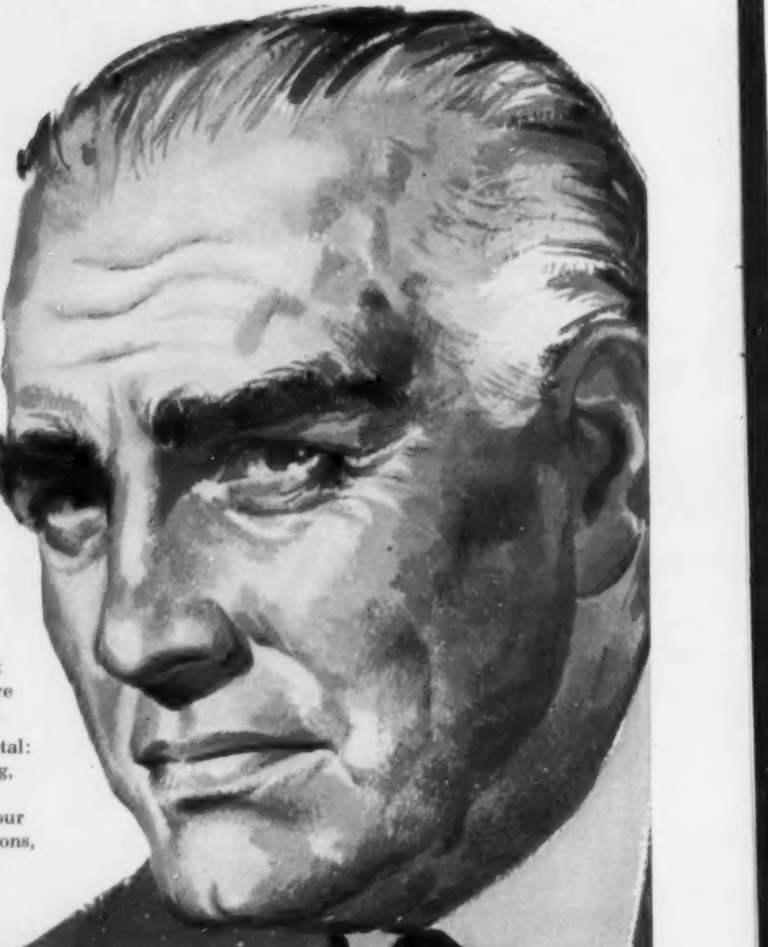

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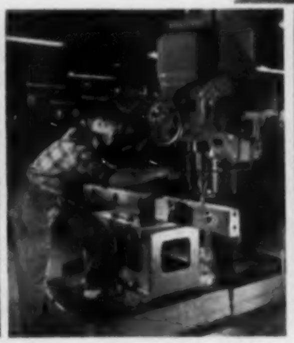

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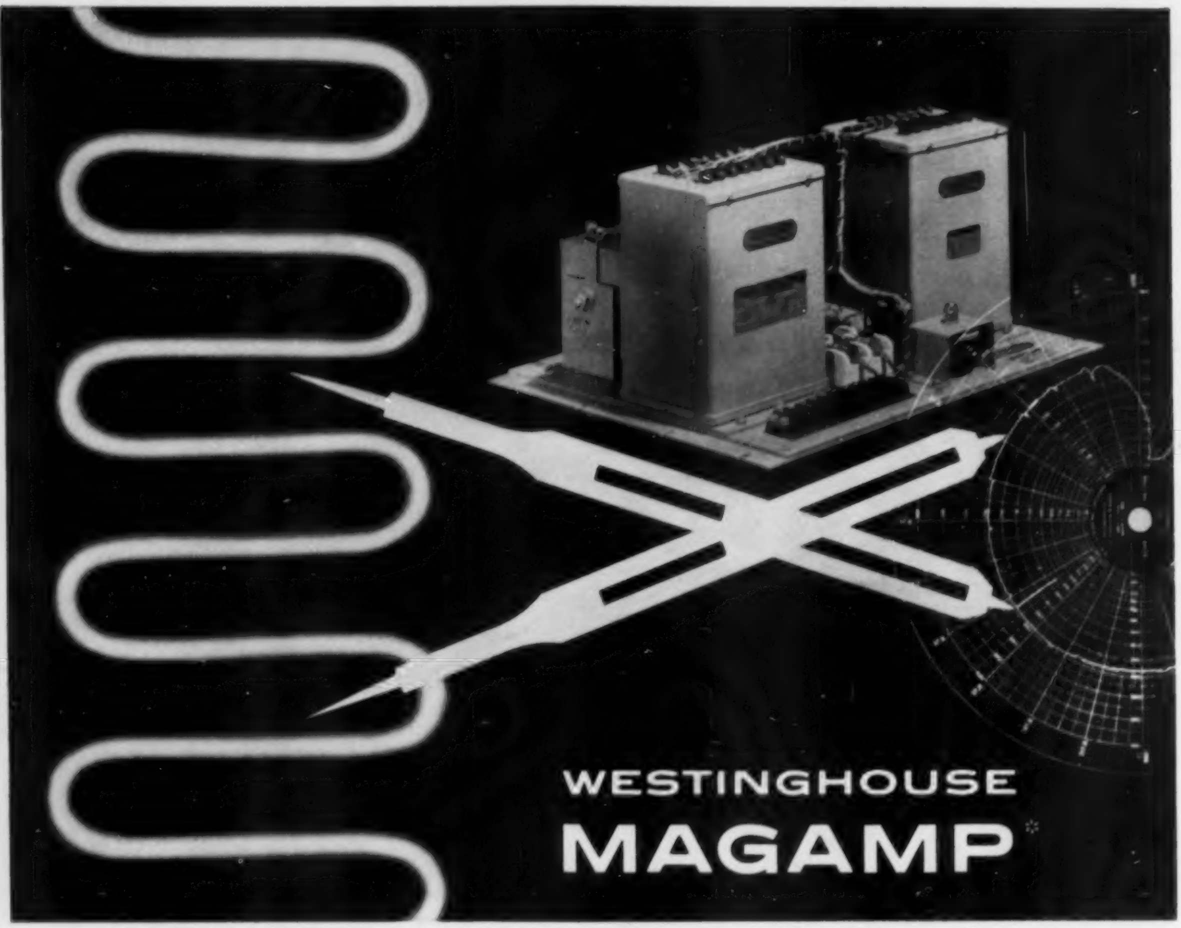
9-54

Shop Superintendent Bonnafe and Gulf Sales Engineer G. R. Burnham check on performance of Gulfcut 51A as turret lathe turns a stainless steel drive roll for a wire belt.



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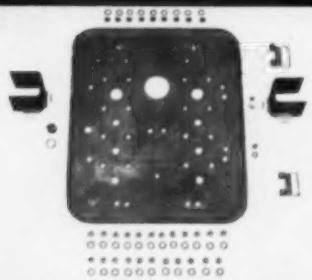

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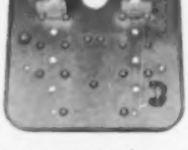

Here's an unusual brazing job, cleverly engineered at Electro-Voice, Inc., one of the nation's leading manufacturers of Electro acoustical products and communication equipment, in Buchanan, Michigan. This unit is a shipboard microphone station manufactured to critical Naval specifications.

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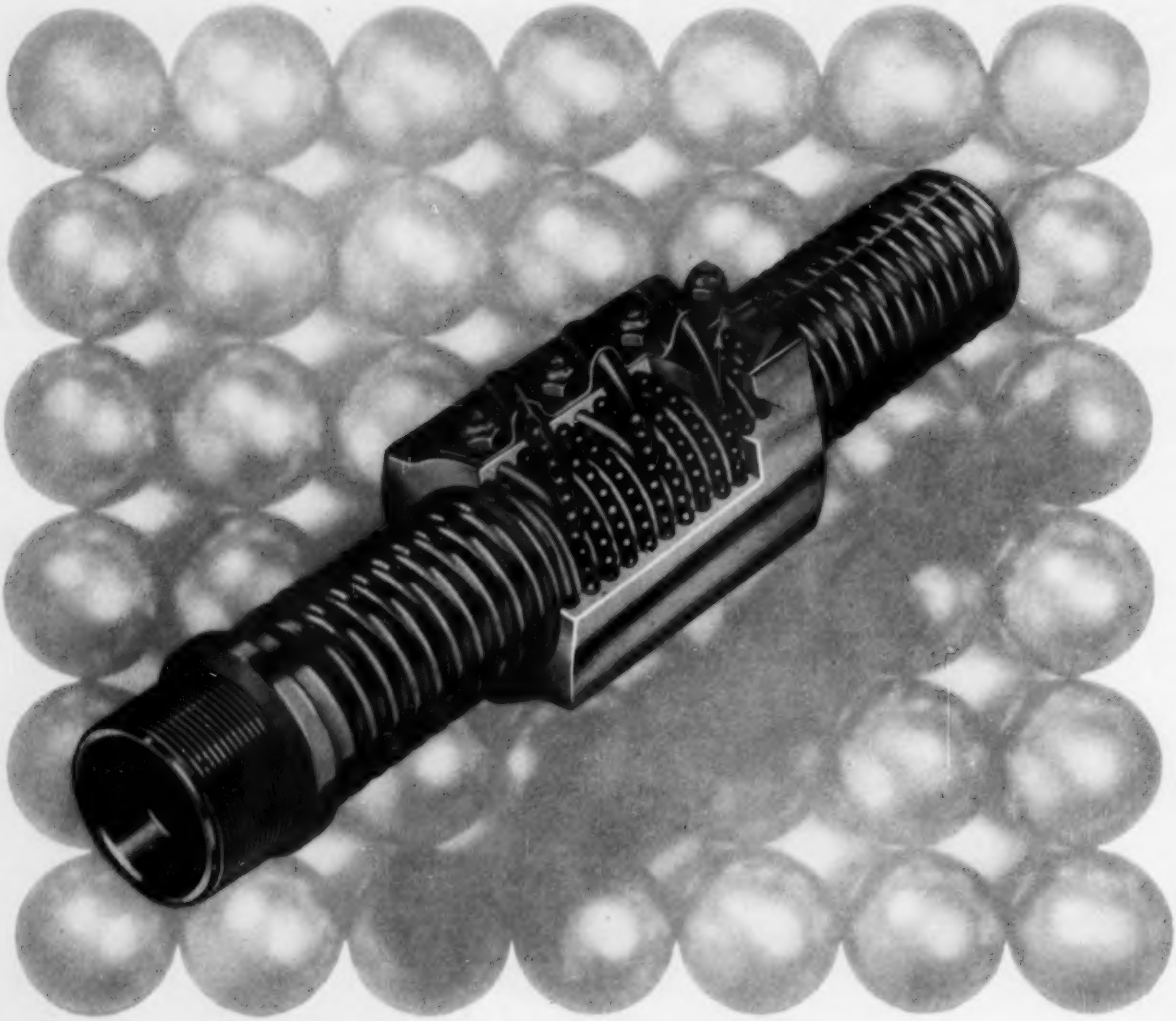

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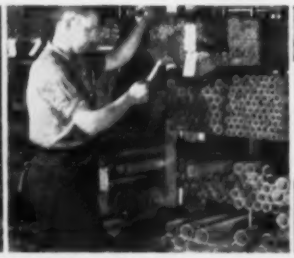

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Metal Progress
Volume 70, No. 5 November, 1956

16-8-2 Cr-Ni-Mo for Welding Electrode

*By O. R. CARPENTER and R. D. WYLIE**

Difficulties cropping up with welded stainless equipment in high-temperature service have led to a new composition which is free from weld cracks and is superior to the usual Type 347 electrode in all respects except resistance to intergranular corrosion. (K 1, T 5, SS)

IN RECENT YEARS the series of chromium-nickel stainless steels (the A.I.S.I. standard Types No. 304 to 347) have become quite extensively used for piping for steam power stations and for components for atomic power generating systems. It is probably true that many of these applications resulted in surprises to the users in the way of fabricating and service difficulties. Not many years ago the austenitic steels were considered to be easily welded, needing very ordinary skill. In some industries, in fact, stainless steel electrodes were often considered to be a cure-all for welding problems. However, many of us have experienced great difficulties with them, particularly where used in heavy sections, and often where employed in high-temperature applications.

Austenitic steels, generally Type No. 347 (18-10 Cr-Ni stabilized with columbium), have been used extensively for steel piping in the public utility field where the steam outlet temperature from the boiler has been 1050° F. or higher. A number of such lines have now had several years' service. In some, cracks in the welds and heat-affected zones have been found during installation and after service. Fabricators of main steam lines and turbine leads have sometimes found their job nearly impossible because of cracking in the weld areas.

Many similar experiences have occurred in

*Quality Control Dept., The Babcock & Wilcox Co., Barberton, Ohio. The work described is from a study made under contract with the U.S. Navy, Bureau of Ships, to study the weldability of 18-8 Mo steels, and the paper was read before the 1955 meeting of the U.S. Atomic Energy Commission's Welding Committee, under the title "The Importance of Weld Composition and Hot Ductility With Respect to Austenitic Weld Cracking".

Fig. 1 – Tensile Test Specimens of 19-9 Cb All-Weld-Metal. The one in the center had composition modified to have some ferrite in the microstructure; the others were completely austenitic

the field of atomic energy. For example, one fabricator of an evaporator using a relatively heavy Type No. 347 tube sheet and a shell welded directly to it, found extensive cracking in the heat-affected zone in the tube sheet. Many American experts studied this failure and just as many opinions were expressed, most of them to the effect that incorrect grain size, melting practice, microstructure or composition was the basic cause. In any event, no clear solution to this problem then existed. While experience has since taught a great deal, the same problems remain with us today, even when an electrode with a controlled and low amount of ferrite is selected.

This summary is given so as to have in mind the 18-8 welding problems faced at the beginning of the development work to be described. In short, welds in the commercial 18-8 type of steels have cracked during welding, as the result of heat treatment, or during service. These cracks may be in the weld metal or in the base material adjacent. Often the repair results in a continuance of cracking so that satisfactory rewelding may not be done.

To understand this defect, we thought it necessary to study the short-time high-temperature ductility of the base material and the weld metal, as well as the welding stresses, as they are affected by coefficient of thermal expansion. Of greatest importance also are the geometry of the welded joint and the size of the structure which, along with welding procedure, determine the level of residual stress in the weld.

Along with these considerations, we should also include other factors, particularly those which directly affect soundness or produce notches in the weld and heat-affected zone. Some of these are microfissures, nonmetallic inclusions, crater cracks, slag and undercuts. Variables in the base material, such as composition and grain size, may

Fig. 2 — Appearance of Samples in Stress-Rupture Tests Summarized in Table III. No. 1 and 2 are all-weld-metal 16-8-2. No. 3 to 6 are joints in Type 347; weld metal in No. 3 is 19-9 Cb; others are 16-8-2

also contribute to cracking. Accordingly, a contract was signed with the Navy Department, Bureau of Ships, to study the weldability of the 18-8 Mo steels, and along with this program many supplementary tests were made on Types No. 304 and 347 base material. This study was divided into four main investigations, as follows:

1. Weld deposit soundness.
2. Satisfactory mechanical properties of the weld and base materials.
3. Adequate properties after service.
4. The effects of weld restraint on the mechanical properties and soundness during heat treatment and service.

This work covered studies of 25 different base materials of 18-8 and 18-8 Mo analyses and 18 different weld metal compositions. While we were primarily interested in finding a satisfactory composition of electrode for welding the 18-8 Mo steels, an important result was the development of a weld material which is relatively free of embrittlement in high-temperature service.

General Procedure

At the outset it will be proper to outline very briefly the testing methods used to study each of the four items listed above.

1. *Soundness* — The Babcock & Wilcox Co. has manufactured welding electrodes since 1928. Lime coatings were first used by us as far back as 1938. This lengthy experience has convinced us that the most satisfactory method of demonstrating weld metal soundness is by a 0.505-in. diameter tension test specimen cut out of an all-weld-metal block, together with a bend test across a welded joint.

2. *Mechanical Properties* — When a material tested as above showed sound metal, it was further evaluated by elevated-temperature stress-

Table I – Stress for Rupture in 10,000 Hr. at 1200° F.

Cr-Ni	Variety	Rupture Stress	Elongation	
			Weld Metal	Wrought Metal
18-8	Cb-Ta	20,000	5.0%	6.5%
19-9		7,800 to 13,000	(a)	14.5
	Low-carbon	9,000	3.0	27.0
	Cb	16,000 to 18,000	6.1	16.0
18-12	Mo	10,500	6.0	38.0
	Mo (low C)	7,700	4.5	18.0
	Mo-Cb	27,000	1.0	—
25-20	(b)	7,000 to 10,500	5.0	—
	(c)	5,000	1.0	—
	Cb	14,500 to 20,500	—	—

(a) Could not be measured. (b) Manufacturer A. (c) Manufacturer B.

rupture tests. Both all-weld-metal specimens and specimens cut transverse to a welded joint in the various base materials were used.

3. *Service Properties* – Weld specimens in pads and in unrestrained butt welds were aged out to a maximum of 10,000 hr., and evaluated by Charpy V-notch impact tests.

4. *Restraint* appear to be one of the more important impediments to sound joints in austenitic materials. Several tests have been used in this work to evaluate restraint, particularly to study its effects during the welding cycle on the eventual mechanical properties, and to measure the susceptibility to cracking of welds during heat treatment and service.

Test Results

Results of the various tests as outlined above will now be summarized. This will show what the problems are and what weld-metal compositions appear to satisfy the desired conditions and avoid previous troubles.

Figure 1 shows a group of fissured tension specimens of fully austenitic 19-9 Cb weld deposits, together with one in the center which was partially ferritic in microstructure. The two at the left had very low extension and multiple fissures occurred along the length. The two at the right had considerably higher and general elongation, but still developed many fissures. The center one (with composition slightly modified so the microstructure is partially ferritic) has good elongation and fractured cleanly.

This photograph shows the value of this test and indicates that unsoundness of the type represented by multiple fissures under tensile stress is overcome by "unbalancing" the composition to produce a partially ferritic weld deposit. This conclusion is well known in American industry, and was well demonstrated by R. David Thomas in his article in *Metal Progress* for July 1956, p. 73. There are several good controlled low-ferrite electrodes now available which produce sound weld deposits, free of fissures. These are not necessarily a slightly modified type of 19-9 Cb. Other successful analyses are 19-9 Cb with 6% Mn, and a 16-8-2 Cr-Ni-Mo combination about which more will be said later on in this article.

Of course, the electrode does not by itself guarantee sound welds. Entrapped slag, lack of fusion, fissuring in the base material, crater cracking (particularly in Type No. 347), and other similar defects cause many unsound welds. Groove design and welding procedure and geometry, therefore, are of equal importance to a sound welded joint.

Mechanical Properties

In addition to composition and welding procedures, other factors determine whether an austenitic weld will give satisfactory service.

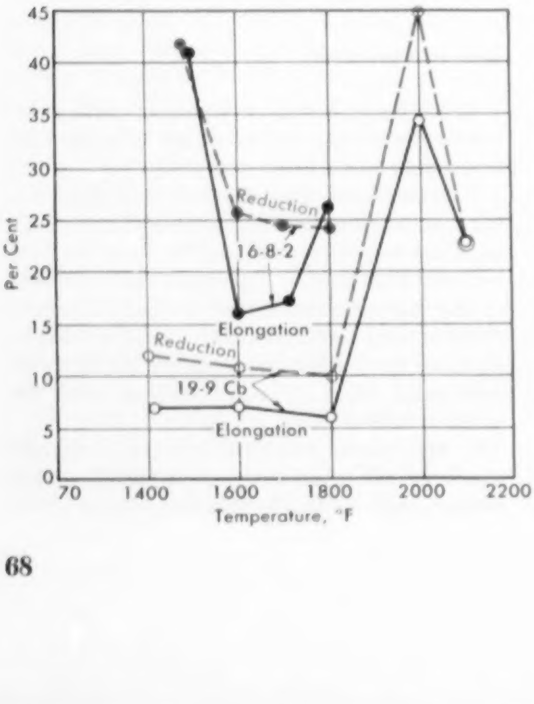


Fig. 3 – Ductility Values in Short-Time High-Temperature Tests Are Better for 16-8-2 Than for 19-9 Cb

Almost all of the weld metals explored in this investigation had good stress-rupture strength, equal to or better than those for wrought alloys of the same chemical composition. However, other good mechanical properties at temperature are also required, such as ductility.

Table I contains a sampling of the stress-rupture data for ten weld metal compositions. Data for only one temperature (1200° F.) and time (10,000 hr.) are selected. In the two colums to the right are given elongations in 2 in.; one as measured from the stress-rupture test of longest life, the other for wrought metals of the same chemical composition. The latter show an important advantage in all tests at all temperatures (1050, 1200, 1350 and 1500° F.). The wrought material has an elongation five or more times better than the weld metal – with three exceptions, one of which, 18-8 Cb Ta at 1200° F. is shown in the table. The other two are 19-9 Cb at 1050° F. and 19-9 (low carbon) at 1050° F., the latter being somewhat better, but not ranked as "good".

This observation of the behavior of the 18-8 series of materials from the point of view of high-temperature ductility led to several very interesting lines of investigation. Figure 2 and Tables II and III are from a series of tests on a composition we have called Croloy 16-8-2 (16 Cr, 8 Ni, 2 Mo). Their elongation values are much better than those of the 19-9 Cb composition in parallel tests.

Table II – Chemical Composition of Metal

Element	16-8-2 Weld Metal	19-9 Cb Weld Metal	Type 347 Base Metal
C	0.07	0.10	0.08
Mn	1.70	1.40	1.72
Si	0.45	0.30	0.43
Cr	15.60	19.60	17.80
Ni	8.20	10.70	12.00
Mo	1.45	—	—
S	0.018	—	0.016
P	0.015	—	0.012
Cb	—	0.75	0.75

Table III – Stress-Rupture Tests

Test Temp., °F.	Condition*	Stress	Rupture Time, Hr.	% Elong.	% Red. Area	Sample in Fig. 2
	All-Weld-Metal Samples					
1200	AW	32,000	71	12.5	21.6	
1200	AW	22,000	2464	20	44	1
1350	AW	15,000	716	17.1	35.6	
1350	AW	11,000	3356	8.6	14.8	
1350	ST	15,000	104	45.6	68.4	
1350	ST	11,000	1659	28.7	51.6	2
1500	AW	8,000	291	—	3.2	
	Type 347 Joints Welded with 19-9 Cb					
1200	AW	25,000	531	—	—	3
	Type 347 Joints Welded with 16-8-2					
1200	AW	24,000	380	—	—	4
1200	AW	22,000	668	—	—	5
1200	AW	19,000	2128	—	—	6

*AW = as welded.
ST = as welded, heated at 1950 °F. for 1 hr., air cooled.

Fig. 4 – Circular Patch Specimen for Studying the Effect of Restraint on Weld Soundness

Also as shown by the photographs of the tests on welds, the material has a high-temperature strength somewhat better than that of Type 347 base material – the fracture is in the base metal rather than in the weld. An actual comparison of the strength of 16-8-2 and 19-9 Cb in welded joints tested at 1200° F. is given in Table III.

The difference in ductility of specimens broken in stress-rupture led to a comparison of the ductility of weld metals under short-time high-temperature testing. If this property is low, we might expect it to accelerate cracking of the material when it is subjected to the restraint of welding. Figure 3 shows the results of such short-time tests of the two compositions (all-weld-metal samples). Notice the poor gage length elongation of the 19-9 Cb weld metal and that this deficiency extends over a wide range of temperature. The Croloy 16-8-2 composition, however, has a minimum elongation of about three times that of 19-9 Cb. Perhaps of more importance, its lower point extends over a much shorter temperature range.

Likewise, the reduction of area of 16-8-2 specimens is in the order of 2.5 times better than 19-9 Cb weld metal at 1800° F.

What significance do these observations have in reference to weld metal soundness and to cracking in the heat affected zone?

Fig. 5 – Block Specimen, 3.75 In. Square and 7.25 In. Long. One slot is completely filled, then the opposite one

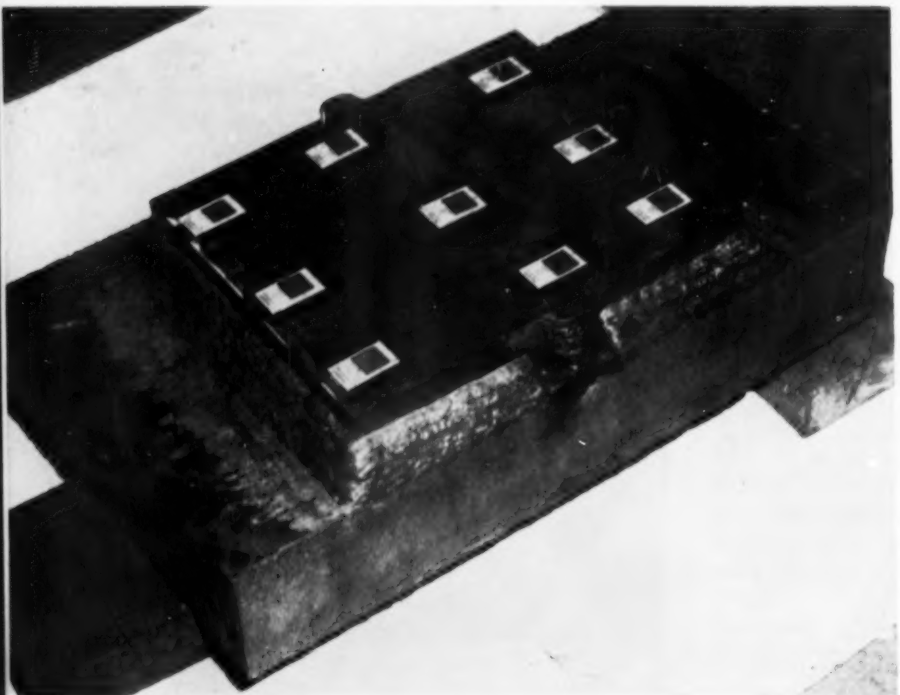


Fig. 6 – "Navy Torture Test" Prepared for Stress Analysis

One may assume that as weld metal is deposited and solidified it establishes tension stresses in and around itself. If the geometry of the joint is such that this region is highly restrained, then the tension stresses must deform the metal at some place, and probably at a temperature where the strength is low and the ductility is poorest. This temperature range has been referred to as the "hot short range", wherein very small amounts of deformation can cause a crack. A notch, a microfissure, or the poor ductility of the metal itself may produce the failures we often experience.

To study this matter, numerous weld restraint tests have been made which will now be described.

Weld Restraint

A satisfactory test of the effect of weld restraint on physical properties has received considerable study. Figure 4 illustrates the familiar circular patch. The plate is at least 4.75 in. square and 1.13 in. thick; the annular groove is 3 in. dia. and 1 in. deep. Its bottom has a 0.31-in. radius and the sides taper away from each other at 15°. A comprehensive stress analysis of such a groove weld in a 12-in. cube of steel, measured as relaxation as the block was sliced, showed circumferential stresses up to 70,000 psi. and radial stresses up to 47,000 psi.

Figure 5 illustrates a square block test we have used quite extensively. The slots are filled in succession with multibead welds. A stress analysis gives a variable stress pattern. The longitudinal stress, in general, increases in each weld from 24,500 at top surface of No. 1 to 41,300 at top surface of No. 4. The transverse stress is the highest in Weld No. 2 (43,600 psi.), 31,300 and 30,500 in No. 1 and No. 4, respectively, and 21,000 in Weld No. 3.

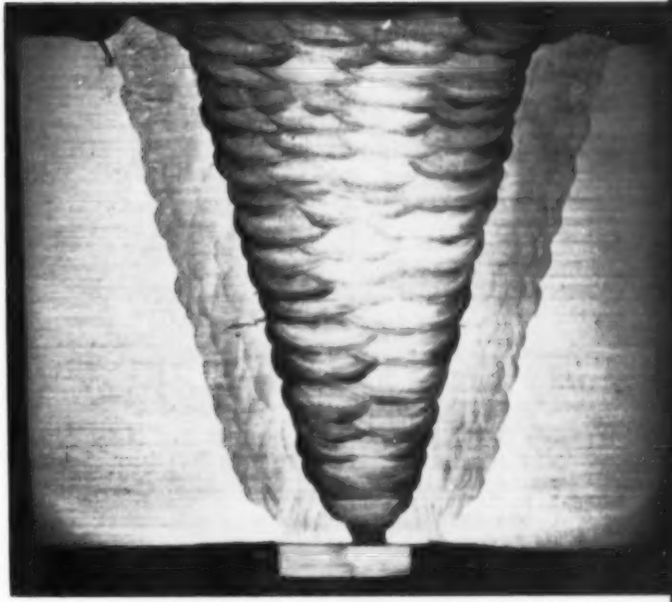
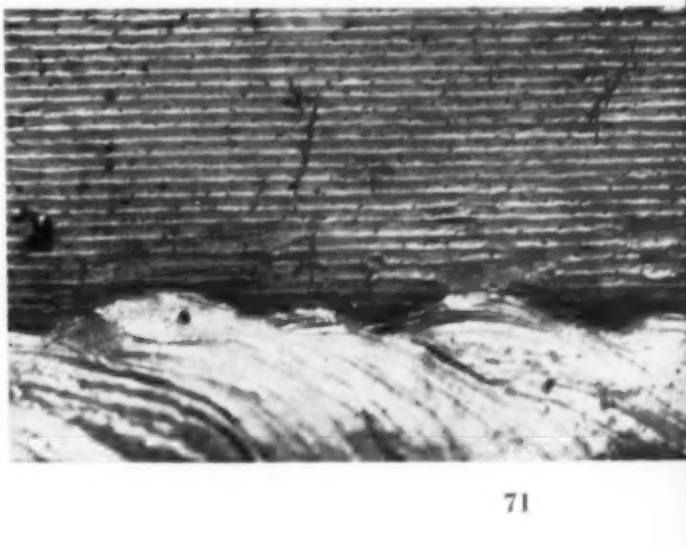


Fig. 7 – "Strain Failure" in Buttered Edge of Base Metal, Probably Due to Lack of Plasticity Required to Relieve Welding Strains During Heat Treatment

The third test which was investigated, the "Navy torture test", is illustrated in Fig. 6. This test showed the lowest stress range – 20,500 psi. compression to 30,900 psi. tension when measured parallel to the groove weld, and 5,800 psi.

Fig. 8 – "Notch Extension Cracks" Shown (Slightly Magnified) Alongside Weld Bead. Micrograph shows them to extend into austenitic crystals

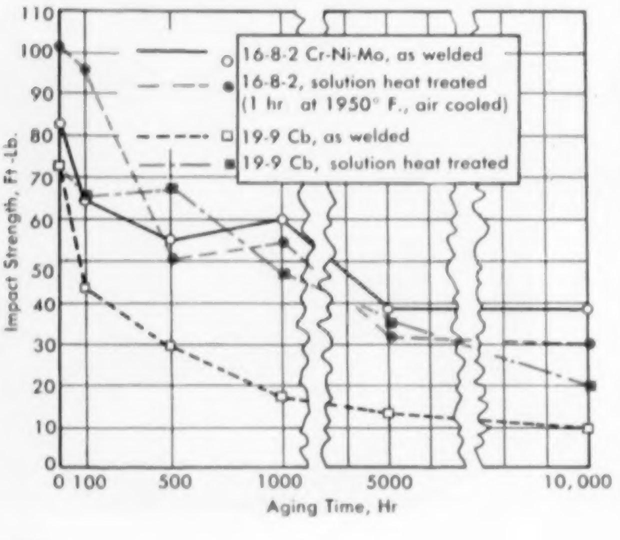


compression to 28,800 psi. tension when measured perpendicular to the weld. It is likely to be the nearest to conditions met in actual practice.

Approximately 86 tests of specimens of these types, using various base materials and weld metal compositions, showed many kinds of cracks. Typical cracking observed in a circular patch test using Type 347 base material and 19-9 Cb weld metal occurs in the bead junctions. The crack contains a metallic island surrounded by oxide surfaces. This is characteristic of cracks found in failures of field welds; it has not been observed *prior* to heat treatment of the weld, but the cracks propagate to a depth of 0.4 or 0.5 in. *during* heat treatment. Because of the magnitude of the stresses in the circular patch test, it is believed that these cracks may be the result of short-time tensile failure, accelerated by any microcracks present in the weld.

Another type of crack observed is illustrated in Fig. 7. It is near the buttered edge of a weld in the base material. Cracks of this type may be initiated by a microcrack present when the joint is welded, but are usually discovered *after* heat treatment. Therefore, the exact cause is difficult to pinpoint, but it appears that this cracking (which progresses on heat treatment) may be the result of the inability of the weld metal to strain or deform during heat treatment as the stresses of welding are relieved. This may set up a metallurgical notch at the line of fusion of the weld which accelerates failure. This type of cracking might be termed "strain failure".

Fig. 9 – Sigma Phase Embrittlement as Measured by Loss in Impact Strength After Long Aging at 1350° F.



Another interesting type is known as "notch extension cracking". This is illustrated by Fig. 8. Varied opinions of their causes are available in the literature. Pellini and Puzak of the Naval Research Laboratory give the most plausible explanation as "liquation" of a grain-boundary constituent adjacent to the weld. Although the nature of this constituent has not been determined, stress resulting from its later solidification may then cause cracks to form at this location. These cracks nearly always run normal to the line of fusion, and frequently extend into the weld, particularly at a point where dilution has made the weld structure totally austenitic (as is shown in the photograph). These cracks are seldom found beneath the surface of the weld, although the bend test coupon will show them as subsurface cracks. Cracks of this type may also initiate further cracking on heat treatment.

Other cracks which propagated and caused trouble in the restraint tests were those resulting from arc strikes. Crater cracking also was troublesome, particularly near the line of fusion.

These restraint tests enabled us to estimate the effect of the degree of restraint on the mechanical properties. For example, we cut bend test samples made from circular patch tests. Columbium-stabilized welds given a high-temperature heat treatment may have poor ductility (cracked badly) when compared to tests on metal as-welded. Unrestrained specimens heat treated in a similar fashion, however, show improved room-temperature properties.

Tensile test pieces cut from all-weld-metal in the square block specimen of Fig. 5 also showed low ductility after heat treatment in 19-9 Cb weld deposits. Other weld deposits made in the same way but of Type 308, 19-9 Cb with high manganese, or Croloy 16-8-2, do not show this loss of ductility. In addition to low ductility, 19-9 Cb welds heat treated under high restraint had as little as 8 ft-lb. impact strength after heat treatment, in contrast to 72 ft-lb. in the same material, heat treated in the same manner, but unrestrained.

It was also observed that an isothermal arrest at 1100° F. during the heat treating cycle did a great deal to improve these results. This treatment may reduce peak stresses prior to the high-temperature treatment.

All of the above results pointed to two principal problems in the weld-

ing of 18-8 alloys: *(a)* high-temperature ductility and *(b)* cracking at notches and stress-raisers. However, these circumstances were consistently absent in welds made with the 16-8-2 composition.

Aging

Before summarizing this test work, one more observation needs to be made with respect to the aging properties of weld metal. This is now important in the utility field, and may shortly be so in the atomic field.

A summary of the aging properties of low-ferrite 19-9 Cb and Croloy 16-8-2, in the as-welded and heat treated conditions, is given in Fig. 9. These tests were run at 1350° F. since other studies indicate this to be more efficacious than either 1200 or 1500° F. The impact strength of a low-ferrite 19-9 Cb electrode in the as-welded condition dropped to 10 ft-lb. after 10,000 hr., and the heat treated 19-9 Cb weld dropped to 20 ft-lb. On the other hand, the 16-8-2 retained good impact strength after 10,000 hr. in both the as-welded and heat treated conditions. Therefore, it does not appear to be metallurgically necessary to heat treat welds made with 16-8-2 electrodes to assure freedom from sigma phase embrittlement.

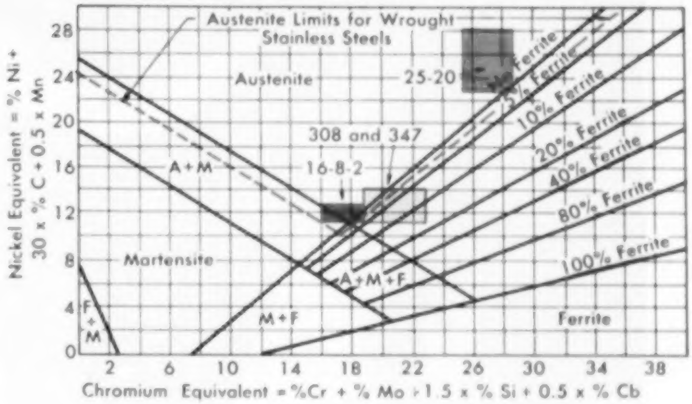


Fig. 10 – The Schaeffler Diagram Showing Amount of Ferrite in Stainless Steels of Varying Compositions

Summary and Conclusions

Experience has indicated a need for a weld metal composition which has reasonable mechanical properties at high temperatures, one which will not embrittle on aging, and one less subject to the cracking experienced in 19-9 Cb welds. In all these respects the 16-8-2 Cr-Ni-Mo composition satisfied the requirements.

Reference to the Schaeffler diagram (Fig. 10) shows that Types No. 308 and 347 weld metals fall to the right of the low angle of the austenite field – in fact, over in the austenite-plus-ferrite field. Although the explanation is vague, it is accepted that a low percentage of ferrite in an 18-8 weld deposit is necessary for consistently sound welding.

These compositions, however, have certain disadvantages, some of which have been described. From the Schaeffler diagram it might be observed that possibly the demarcation between an austenitic structure containing ferrite and one containing martensite is, in some composition ranges, a very narrow one. If, therefore, the composition is moved to the left and at the confluence or low point, staying either fully austenitic or austenitic with some martensite, would satisfactory results be obtained?

The Croloy 16-8-2 is this type of composition. The series of tests run indicates that none of the problems common to the 19-9 Cb (Type No. 347) welds are present in these weld deposits. With the exception of susceptibility to intergranular corrosion, it equals or betters all of the mechanical properties of Type No. 347.

To date, the Babcock & Wilcox Co. has made and used about 30,000 lb. of this electrode composition. No fabricating problems have been found. There has been complete freedom of cracking – with the exception of a very few scattered crater cracks. About eight utility companies and one university are now running independent tests on it. In three instances where field fabrication of steam leads by utilities proved to be impossible with Type 347 welds, 16-8-2 was substituted with success. It has been used to fabricate the 18-8 components for the first 4500-psi. supercritical boiler.

These applications and test results lead us to believe that a weld deposit in the 18-8 range of composition must primarily have sufficient hot ductility to enable it to move under the restraint of the joint without mechanical failure – particularly at notches – at the temperatures at which the stress is imposed. Of course, sound welding judgment and procedures may be of equal importance, especially if such procedures are developed with an aim of keeping the residual stresses in the welded structure at a minimum.

Genie of the Magnet

A new magnetic material, developed by Westinghouse, starts with manganese and bismuth of highest purity. These are ground to impalpable powder, mixed in stoichiometric proportions, converted to the compound MnBi by heating just under the melting point of bismuth, and then repulverized. All these operations are done in helium atmosphere, because MnBi is pyrophoric – as shown by the shower of sparks as a little powder is scattered in the air. To make a magnet, the ground MnBi is mixed with a little plastic binder, molded to the desired shape, and the binder sets while the piece is in a powerful magnetic field. Every particle of metal is a tiny magnet and they are properly oriented during this operation; the result is a magnet of unusual permanence – that is to say, it has very high coercive force – and consequently can be safely used in electrical meters and other devices which may have to operate and retain their accuracy in or near external magnetic fields set up by other machinery.

Magnesium and Calcium as Metallurgical Reducing Agents

*By L. M. PIDGEON**

Reactive metals, such as titanium, zirconium and uranium, are produced by reduction of their halides or oxides with magnesium or calcium. (C 26)

THE THEORETICAL ADVANTAGES and limitations of using magnesium and calcium as metallurgical reducing agents were described in two earlier articles (August and October) in this general review of the scientific principles involved in the production of reactive metals. How these principles are used to determine the actual production techniques is indicated by examination of the operations of commercial producers of these metals.

The most obvious example of this type of reaction is found in the production of titanium. This metal has proved to be very troublesome to produce and to handle. The liquid tetravalent chloride is not ionized although the subhalides are said to ionize. Suboxides exist and, in fact, titanium metal hangs on to oxygen with increasing tenacity as the oxygen content decreases, so that the activity of oxygen in a titanium containing less than 1% oxygen is very low indeed. Most unfortunately, traces of oxygen exert a powerful and unfavorable effect on the physical properties of the metal.

Oxide Reduction

Only calcium and magnesium need be considered as possible reducing agents for the oxide; lithium is too expensive and aluminum forms alloys with titanium. Magnesium is partially effective, and it is known that reaction between magnesium and TiO_2 takes place autogenously, but not all the oxygen can be removed from TiO_2. Calcium is, on the other hand, a very effective reducing agent and oxygen values as low as 0.07% can be obtained by calcium reduction. A combined reduction method involving both magnesium and calcium has been suggested which has the obvious advantage of more extensive use of the cheaper reducing agent.

The high melting points of all the reactants in these systems indicate that there is no hope of achieving separation of products during the reaction; hence, MgO or CaO and Ti will exist as more or less fine powders. The alkaline earth oxides must be removed by acid leaching. The titanium powder produced is useful in certain applications.

Halide Reduction

Most titanium is now produced by the reduction of $TiCl_4$ with magnesium using the Kroll process. The oxide is first converted to the tetrachloride by a reaction such as

$$TiO_2 + 2\,Cl_2 + 2\,C = 2\,CO + TiCl_4$$

This reaction is general for oxides and because of the higher heats of formation of chlorides, produces a considerable amount of heat. The gaseous nature of $TiCl_4$ permits the use of a distillation process to achieve a pure product.

The gaseous $TiCl_4$ is added at controlled rates to a closed system containing liquid magnesium and an inert gas. At temperatures of about 800° C., the reaction proceeds smoothly. Liquid $MgCl_2$ is removed at intervals and titanium sponge is produced. Residual $MgCl_2$ is drained off and the remainder is removed by vacuum distillation.

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Zirconium

Zirconium is produced by reduction of the tetrachloride with magnesium in a manner analogous to the titanium reaction. Differences are due entirely to the differences in physical properties of $TiCl_4$ and $ZrCl_4$. The latter is solid at room temperature and may be readily sublimed at about 300° C. The process involves the reaction of zircon with carbon to form zirconium carbide which in turn reacts with chlorine to form the tetrachloride. The gaseous tetrachloride is purified by distillation and then reduced with magnesium.

In the purification step, the tetrachloride is sublimed in a vacuum chamber onto a cooling coil which may be removed readily from the apparatus. The condensate plus cooler is placed in a reaction chamber containing magnesium. The latter is heated to about 900° C. and the cooling coil and its condensate heated until an effective pressure of $ZrCl_4$ is produced. An exothermic gas-liquid reaction takes place between magnesium and $ZrCl_4$, the rate of which is controlled by the addition of $ZrCl_4$ and removal of $MgCl_2$ from the reaction zone. A sponge is produced since the melting point of zirconium is well above the temperature in the chamber.

Thorium

Thorium may be produced as a powder by direct reduction of the oxide. The maximum driving force is required here; hence, calcium metal is employed. The CaO is removed by acid leaching as in the production of titanium powder by oxide reduction. The powder is sintered in a vacuum to produce massive thorium.

Rare Earth Metals

The rare earth metals have been receiving increased attention in recent years although only very small amounts have as yet been produced. The most common form of the rare earth metals is a mixture of cerium and other metals known as misch metal. This alloy is produced by molten salt electrolysis.

The preparation of pure metals is readily achieved by reaction between the anhydrous chlorides and calcium metal in a steel bomb. The bomb is heated to 700° C. which is sufficient to initiate the reaction. Iodine is sometimes added to render the reaction more exothermic. The metal produced is fused and may be separated readily from the $CaCl_2$.

The higher melting metals are prepared in a tantalum crucible and no booster is required. At higher temperatures, it is necessary to use fluorides to keep pressure down to safe limits. The use of boosters is necessary when the "shot" is of small size. Large masses with their lower surface-to-volume ratios rarely require such assistance.

Beryllium

This is a metal of specialized uses and is produced in reasonable quantities. It is formed by the reduction of beryllium fluoride with magnesium. In this operation, a liquid mixture of BeF_2 and MgF_2 is treated with magnesium. Small successive additions of magnesium are made so that at all times an excess of BeF_2 is present. A liquid-liquid separation of beryllium on the fluorides is achieved.

This type of operation is similar in principle to the Kroll process for titanium. At the operating temperature, the magnesium is gaseous. In the Kroll process, the $TiCl_4$ is gaseous at operating temperatures. In both instances, the volatile reactant is added gradually and an excess of the other reactant maintained.

Uranium

Uranium metal has been produced for many years by the reduction of either its oxide or halide with calcium or magnesium. With a melting point of about 1115° C., uranium can be melted during the "shot".

Less Reactive Metals

Many less reactive metals may be produced by reduction with magnesium; for example, chromium is produced by the reduction of chromous chloride. The reaction is carried out in an iron crucible lined with sodium chloride. Reaction between magnesium and $CrCl_3$ occurs before the NaCl melts. The reaction is, therefore, carried out in an effectively iron-free system. The retort is heated at the top, filled with helium and the temperature raised to 800° C. The reaction starts at 500° C.

The chromium is not melted, of course, and remains as a powder. Mixed chlorides are removed by vacuum distillation at 800° C. and 0.001 mm. pressure.

Vanadium has been produced in massive ductile form by calcium reduction of the pentoxide in the presence of 5 to 6% of sodium oxide and some sulphur. The reaction is also conducted in a bomb.

The Use of Calcium Hydride

A special process which is important in many fields is the use of calcium as the hydride which is formed by direct reaction between the metal and hydrogen gas. The reaction is exothermic and self-sustaining, and proceeds smoothly between 400 and 600° C. The hydride contains excess calcium and, in fact, a wide range of composition will be in equilibrium with hydrogen at various temperatures and pressures. The hydride is a white powder which is easily handled and is much less reactive to atmospheric gases than is calcium. It offers certain advantages where fine powders are required. It reduces many oxides, and where stable hydrides of the metal exist, such a hydride will be the product of the reaction.

Titanium hydride is produced by heating CaH_2 with TiO_2. The reaction is carried out at quite low temperatures so that the hydride is not largely decomposed. Presumably, all reactants and products are in the solid state, although the hydrogen equilibrium must be considered in each instance. The CaO is removed by acid leaching and powdered TiH_2 remains. This product may be pressed into compacts and sintered in vacuum to produce solid metal.

Zirconium is produced in a similar manner. Hydride powders and metals produced by decomposition of hydrides appear to have special properties suitable to certain applications.

Book Review

Handbook of Foundry Practice

*By FRANCIS W. BOULGER**

THE CASTING OF STEEL, edited by W. C. Newell, Pergamon Press, London, 1955, 600 p. 105s.

IN ADDITION to its publicized effects on modern life, science has managed to complicate such ancient crafts as foundry operations. It is no longer sufficient to cause steel to freeze in molds of approximately suitable dimensions and to classify the casting as "hard" or "soft". Foundry techniques must be continually improved in order that accurate shapes will have properties suitable for specialized applications and compete with products made by other methods. To be successful in striving for improved quality and productivity, a foundry must integrate the effort of men with a variety of skills and technical backgrounds. It is unfortunate, but probably characteristic, that a specialist becomes so engrossed in his particular contribution that he neglects the importance of other factors involved in the operation. Consequently, it's easy for a molder to blame the metal and the melter to blame the sand when things go wrong in a shop. This recent English book is an attempt to acquaint the scientist and the skilled workman with the contributions of his co-workers to successful foundry operations.

One has come to expect the British engineers and metallurgists to exhibit a broader grasp of the problems and operations of their industry than their American counterparts. Consequently, it is a little surprising that the British saw the need for a book covering all phases of foundry technology. On the other hand, it may be that generalized books of this kind keep them well-informed.

"The Casting of Steel" is a joint effort by 15 authorities in different fields of foundry technology. Because the subjects of the various chapters were selected to avoid duplication of effort, some gaps in coverage are noticeable. The chief advantage of the plan is that it permits each contributor to discuss his specialty in a straightforward, authoritative manner. Some authors felt no compunction to list more than a few references; however, this lack of annotations should not be important to the audience to which the book is directed. The editor, W. C. Newell, is well known as the former head of the Steel Castings Div. of the British Iron and Steel Research Assoc. His efforts were concerned primarily with the scope of the book and harmonizing the presentations so that the style and

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viewpoint of the articles shift occasionally. The text is readable and easy to follow and the illustrations are first-rate.

Most of the authors treat their subjects in a consistent manner. They introduce their topics by considering basic principles and proceed to descriptions of practical problems and operations. Except in a few chapters, the discussions are of the survey or generalized type. The comparative lack of specific and detailed information prevents "The Casting of Steel" from being a conventional "how-to" or "why" book. The presentations are intended primarily for design engineers, inspectors, foundrymen and students interested in foundry operations. Readers in these categories will find considerable information to interest them. Metallurgists, ceramic engineers and other specialists will find the book a useful source of general information on arts related to their field. However, it is not apt to be a likely source for useful information in his own specialty. A metallurgist should consider the book as a supplement to his library on steelmaking and metallurgy of steel castings.

To be a little more specific, chapters on radiography, nondestructive testing, centrifugal casting and investment casting discuss subjects not treated adequately in older books on foundry technology. The 200 pages on molding materials, pattern making, molding and coremaking should prove informative to many readers. A fair proportion of the descriptive material and references is keyed to American practices or publications. For this reason and because of the general similarity of terminology used by foundrymen in the two countries, American readers should have no trouble in using the book. Except for the descriptions and data on British sands, machines and testing equipment, most of the information is of general application.

Quality Control Through Heat Treatment

*By JOSEPH J. WARGA**

The consistent high quality required in heat treated aircraft components can be obtained only if heat treating equipment is properly maintained and manned by adequately trained personnel. (S general, J general)

Quality cannot be inspected into a heat treated part – it must be induced during the manufacturing cycle. Aircraft parts which are designed for maximum strength and minimum weight are always carefully inspected, but only by reliable process control can we be assured of obtaining the best properties consistently.

The two most important aspects of manufacturing quality control are maintenance of equipment and maintenance of personnel attitude. These inseparable two are the key to consistent top-quality heat treatment. A poorly informed careless operator can cancel the advantage of excellent equipment, and the excellent personnel cannot produce satisfactorily with poorly maintained equipment.

To maintain personnel attitude, all new jobs are discussed in detail with the operators who will run them. Records of operating settings are kept on file and are available to the operators. Regular meetings are held to discuss ways and means of reducing rework or scrap. (This

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does occur even with the most exacting safeguards!)

All furnaces are equipped with controlling and recording potentiometers except the low-temperature drawing ovens, which are controlled by Partlow mercury bulbs. All tempering furnaces and ovens are fitted with fans to circulate the atmosphere for minimum temperature variation.

Temperatures of loaded furnaces are checked daily with a portable potentiometer and a calibrated thermocouple, and the furnace temperatures and check temperatures are recorded in a log book. Thermocouples of carburizing furnaces are replaced monthly and the withdrawn couples are examined, cleaned and saved for further use, or discarded. Every two months, all pyrometers are checked for accuracy and for wear of parts by an instrument servicing company retained for that purpose.

All tempering furnaces are vacuum cleaned at the beginning of weekly operations. At the same time, carburizing furnaces are examined for sags and leaks in the retorts. Atmosphere furnaces are blown clean of carbon particles at least once each shift, and quite frequently at least twice.

Carburizing and atmosphere furnaces are throtttled at 1200° F. over the weekend, and are conditioned prior to starting daily operations. Proper conditioning is checked by means of a small loop of bailing wire. If, after at least 15 min. exposure to enriched atmosphere in the furnaces at 1600° F. or above, the loop is brittle when quenched in water, the furnace is properly conditioned and ready for operations. No carburizing or atmosphere furnace is used until it is properly conditioned. In addition, periodic checks are made of generated atmosphere and individual furnace atmospheres with an Alnor Dewpointer.

All furnaces are numbered and the control panels, contactor boxes and main switches of each furnace are identified with the same number as the particular furnace. Each control panel is furnished with a peg from which is hung a clipboard. This clipboard serves primarily as a holder for the heat treating instructions but also has printed on it the specifications of the furnace. By consulting the clipboard, the heat treater knows exactly what he should do with each part to be heat treated. Special instructions applying to the maintenance of the carburizing furnaces and the atmosphere generators are also hung from clipboards.

A vapor degreaser is located immediately outside the working area. All parts are degreased before heat treating and after oil quenching.

Carburizing is performed in pit-type furnaces with atmospheres prepared either by cracking a hydrocarbon liquid or by the addition of propane to an endothermic carrier gas. Two furnaces are equiped with carbon potential controllers and these furnaces are also used for carbon restoration. Because of the wide range of case depths encountered in our operations, carburizing is performed between 1600 and 1725° F. By carburizing the parts of shallow case depth at the lower temperatures, we believe we have better control of case depth.

Case depth is controlled by means of rectangular specimens hung in the ports of the furnaces. These are pulled by the operator before the load is scheduled to be shut down, and quenched in water. They are then reheated to 1475° F., quenched in water, fractured by bending, etched and examined with a Brinell microscope. Although the carburizing cycle is noted on the heat treat ticket, it is the operator's responsibility to adjust the time if the examination shows the case to be shallower than desired.

All long carburizing cycles performed in a carbon-controlled furnace are two-stage. For instance, the carburizing cycle to obtain 0.048 to 0.055-in. effective case depth on a specific 9310 part would consist of 5 hr. at 1700° F. and 1.15% C, followed by 4½ hr. at 1700° F. and 0.85% C. The finishing carbon potential for 3310 steel is also 0.85%, while 4620 and 8620 are finished at 0.95% C and 1020 at 0.95% or even 1.10% C. A minimum of 4½ hr. at the lower carbon setting is one of our requirements and it means that the shallower case depths are treated at but one setting. In the carburizing furnace without carbon control, a diffusion cycle without fluid or propane is mandatory, regardless of the case depth. The ratio between carburizing and diffusing cycles may be anywhere from 1 to 1 up to 4 to 1, depending upon the material and the carburizing temperature.

Nitriding is performed on the nitralloys and on low-alloy steels of the 4140 and 4340 grades. Manufacturing control is exercised by controlling the temperature and the dissociation. The operator is required to make periodic checks of the dissociation (by pipette) at least every two hours. Nitralloys are given a two-stage diffusion cycle and during the transition from the initial to the final dissociation, the operator checks every half-hour until the desired dissociation is maintained.

Copper plate is used to mask surfaces which must be free of nitrides. Where the geometry

of the part makes it difficult to obtain proper coverage by copper plating, a proprietary paint is used. Operators are issued clean gloves to keep surfaces free of soil and perspiration.

When a new part is scheduled for nitriding, one or two samples are first processed individually. These samples are given dimensional measurements before and after nitriding, and if necessary, adjustments are made in the original dimensions to bring them within the required finish tolerance. Once these adjustments are made, the various machining tolerances and all heat treating conditions are adhered to.

Virtually all hardening is performed in controlled-atmosphere furnaces. Each furnace is supplied with an auxiliary propane line and a natural gas-air line so that the atmosphere can be adjusted to suit the material to be treated. In this way, a constant setting can be maintained at the endothermic atmosphere generator.

The temperature of the oil used for quenching is maintained at 125° F., although a range of 100 to 145° F. is permitted. Each of the two oil quench setups has its own heat exchanger. The quench line for the quench presses has a coil heater but it is seldom used except during the colder months when the oil cools to about 65° F. over weekends. The oil in this line is circulated continually through the quench presses into the storage tank and through the heat exchanger. Circulation is adequate to maintain a rolling action out from the center of the storage tank. The second quench line consists of a distributor-type quench tank and closed storage tank.

It is our practice to flash copper-plate carburized parts prior to hardening. The atmosphere is then adjusted to be slightly carburizing in order to keep the copper free of soot or oxide. Carburized surfaces will be neither enriched nor depleted during hardening and no carbon pickup will occur on uncarburized surfaces coated with copper.

Preheating is not usually employed; however, the part is not allowed to come in contact with the hot hearth. It is either placed on fixtures, racks, trays or wire mesh. The times noted on the heat treat instructions are total times at the indicated furnace temperature and take into account whether the part is placed in a hot furnace or whether it is brought up to temperature with the furnace.

Our goal in hardening is to obtain a minimum of 80% martensite at the center of the part during quenching so that the tempered parts will have the best combination of mechanical properties. Section thicknesses are carefully examined in order to ascertain that the part can be properly hardened in oil. If the part is especially critical, the end-quench hardenability of the heat from which it was made is checked. If section thicknesses are too great to harden at the time of heat treatment, then one of three alternatives is pursued – the section size is reduced, the part is given an interrupted quench in water (4130 and 8630 only) or a change in alloy is requested.

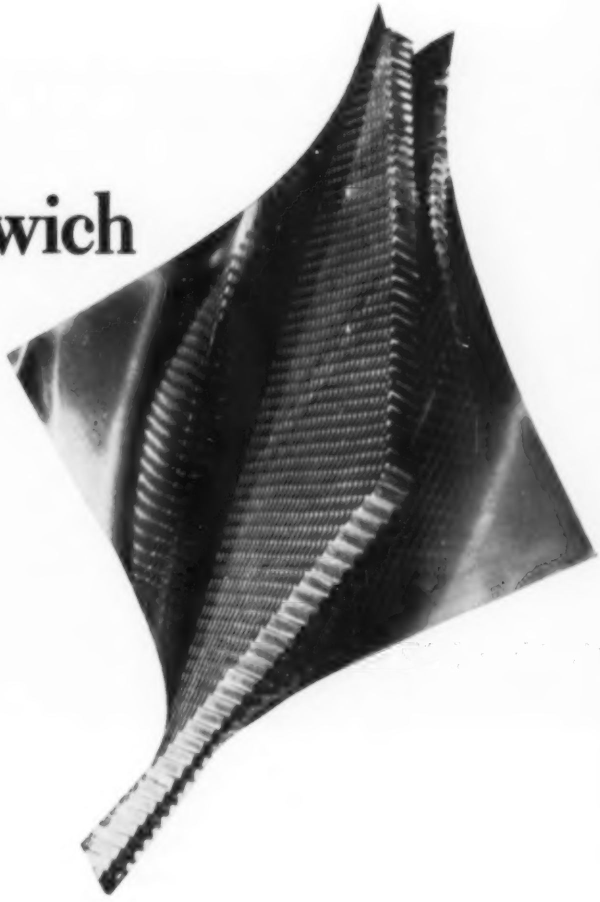
The leadmen are required to check the hardness of the as-quenched part and record it on the heat treat ticket. They are furnished with a list of the minimum as-quenched hardnesses that should be obtained. If the as-quenched hardness falls below the listed minimum, they are to report the fact to the supervisor for his action. Hardness of the tempered part is also checked on a percentage basis and no part is taken to the inspection area until the check has been satisfactory.

In addition to checking hardness, the leadman is responsible for seeing that dimensional checks are made on die quenched parts. In most instances, this is a check on the first piece to verify that the die setup is correctly aligned. However, when the part is particularly critical, it is checked more often in order to catch any change in dimension as quickly as possible and obviate the necessity for reheat treatment.

The primary control exercised in the heat treatment of aluminum alloys is by maintenance of equipment. Both solution annealing and precipitation hardening furnaces are checked to see that a low temperature gradient is maintained throughout the furnace. An additional safeguard is used when solution annealing 2024 aluminum alloy. The load is placed in a tray or basket and a thermocouple is introduced into the center. While the temperature is controlled primarily by the potentiometer circuit of the furnace, it is monitored by the lead couple connected to a portable potentiometer.

The procedures enumerated herein did not spring full grown as Athena from the brain of Zeus nor did they "jest grow" like Topsy. They are the result of evolution; all departments had a hand in shaping them as requirements for greater economy coupled with better quality became an operating necessity. We have not hesitated to copy the successful practices of other firms, for evolution implies a continual series of challenges and solutions. As further advancements are made in heat treating and in aircraft alloys, further modifications and refinements will result.

Production of Honeycomb Sandwich Structures



*By GEORGE D. CREMER**

Strong lightweight structures can be made by bonding two thin sheets of a strong material to an expanded honeycomb core. Adhesives are used for low-temperature service, brazed or welded joints for the new high-temperature applications. (T 24, K general)

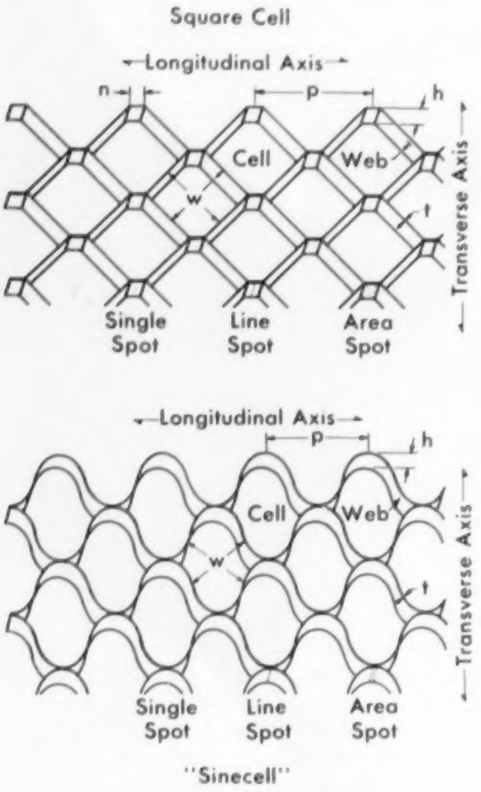
THE SURFACE LAYERS of both modern metal buildings and modern aircraft are designed to conform to their environment. In buildings, the design is based on appearance and the surrounding structures. On an aircraft, the shape of the skin is determined by the speed and altitude at which the plane is to fly. For both, the surface layer must be light, rigid and self-supporting, and should be as thin as possible so that the greatest amount of interior space can be available for use.

Laminar or structural sandwich construction has been used increasingly for both applications in recent years. The sandwiches are usually composed of two thin sheets of a strong, heavy material surrounding and tightly bonded to a lightweight core. Historically, the deHavilland Mosquito bomber of World War II was the first aircraft in which sandwich construction was used in appreciable amounts successfully. The sandwich was made with birch plywood-type facings and a balsa core. Later, Chance Vought Aircraft, Inc., developed a sandwich with high-strength aluminum alloy facings bonded to end-grain balsa core. The product, called Metalite, was used in the F5U, F6U and F7U naval aircraft.

From an engineering standpoint, solid cores are not completely satisfactory. Differential expansion may cause warping or break the bond. The weight of the sandwich is less than a solid section of the facing material of equivalent structural stability but additional weight reduction is desirable, especially in aircraft.

A vastly superior core is one made from a dense high-strength material which has been formed into an expanded or cellular network. Such cores look like a cross section through a beehive comb, hence are called honeycomb. Glenn L. Martin Co. pioneered the development of honeycomb core sandwich, and it is now used in literally hundreds of applications. Cores are made of impregnated paper, reinforced plastics, aluminum alloys and steel. Both aluminum and treated paper are used in the metal curtain walls

*Senior Staff Engineer, Research Div., Solar Aircraft Co., San Diego, Calif. This article is based on an eduational lecture presented to the Los Angeles Chapter.



Nomenclature of the Square Cell and Sinecell Honycomb

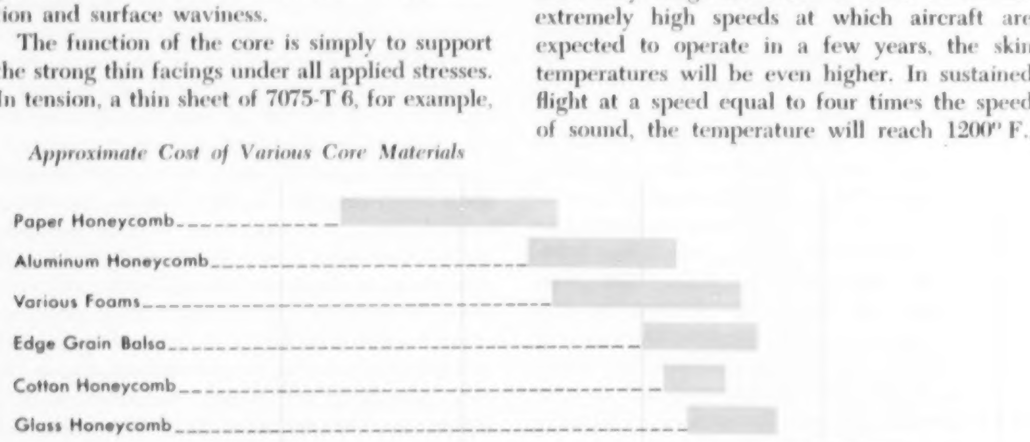
of buildings, and have eliminated two major problems of solid core construction – delamination and surface waviness.

The function of the core is simply to support the strong thin facings under all applied stresses. In tension, a thin sheet of 7075-T 6, for example, could support up to about 70,000 psi. but if loaded in compression, would fold or buckle at very low stresses. Since the basic compressive strength is approximately the same as the tensile strength, the stabilizing effect of the core permits the sandwich to support equivalent loads in tension or compression. It is stiff, rigid and smooth-skinned and has better thermal insulation and vibration damping characteristics than a solid structure of equal strength.

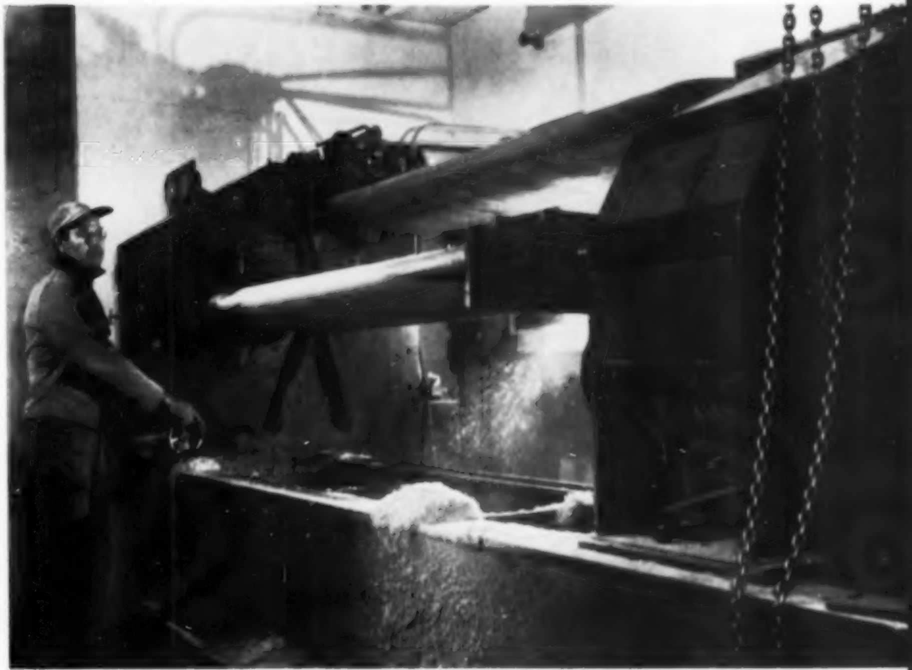
Design of the honeycomb is still a matter of controversy, and selection of the size and shape of the cell and web thickness is based on experience, production cost and the judgment of the designer. The greatest volume of core is produced from resin-impregnated paper, and the honeycomb cell is approximately hexagonal in shape. The hexagonal shape is most suited for adhesive-bound sandwiches. Metal honeycomb that is to be brazed or welded usually has square cells but if some draping or contour forming is required, a sinecell or corrugated shape is used.

Hundreds of thousands of square feet of aluminum alloy honeycomb has been used in aircraft construction, but the speeds of future aircraft will limit its use to internal structures. The sandwich panel is bonded by resin adhesives, some of which can be used at temperatures of 350 to 400° F. Unfortunately, many of the aircraft components for which honeycomb construction would be most advantageous must operate at much higher temperatures. In regions surrounding the jet engine, for example, temperatures may range from 800 to 1800° F. At the extremely high speeds at which aircraft are expected to operate in a few years, the skin temperatures will be even higher. In sustained flight at a speed equal to four times the speed of sound, the temperature will reach 1200° F.,

Approximate Cost of Various Core Materials



Ice Is Used to Support Honeycomb During Machining



much higher than any adhesive bond could withstand.

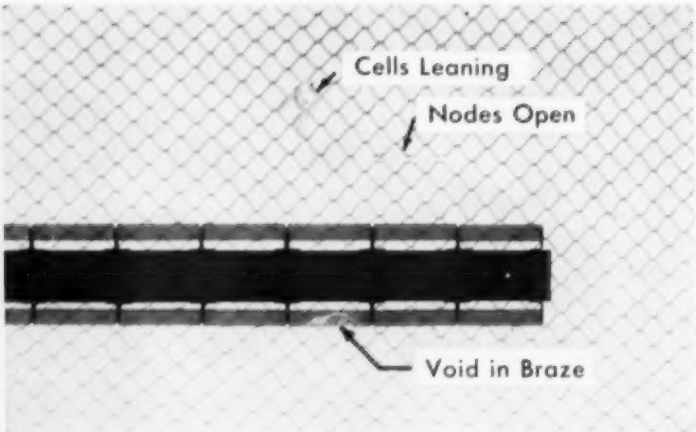
The only answer to the high-temperature problem is an all-metal brazed or welded sandwich. Stainless steel core, ⅜-in. cell size, can be obtained for about $75 per cubic foot but the cost skyrockets if special heat resistant alloys or smaller cell sizes are used. For example, 0.002-in. L-605 foil costs approximately $40 per lb. in small lots and each cubic foot of ⅛-in. cell core contains 10 lb. of foil. Manufacturing and cutting the core increase its cost significantly.

Two methods have been evolved for manufacture of honeycomb cores—full-open or compressed. In the full-open method, the ribbons of foil are corrugated or otherwise formed directly to the core shape and the ribbon elements assembled node-to-node and glued, welded or brazed. The compressed core, called "hobe" (honeycomb before expansion), is made on fully automatic machinery and is expanded as required. Hobe is easier to handle and ship and it can reduce the tooling cost of many of the simpler machining operations. Whether core is supplied as hobe or in the full-open condition, machining of some sort is frequently necessary. Contour, tapers, inserts, lap strips and edge attachments all require precise core removal or surfacing. The nonmetal and aluminum cores are amenable to fairly conventional machining operations. Steel and high-alloy cores, on the other hand, present very difficult machining problems. These materials are inherently tough. Burr-free core ends are mandatory for high-temperature all-metal sandwich in distinct variance with adhesive-bonded sandwich requirements. To complicate the picture, high-temperature joining methods involving brazing require that the core be surfaced within ± 0.001-in. local deviation.

Unexpanded core or hobe is machined readily by conventional tools providing adequate clamping pressures are used. Obviously, dimensional allowance may be necessary for when the hobe is subsequently expanded the longitudinal ribbon direction shortens about 20%. For sandwich applications involving tapered or otherwise contoured core, machining in the expanded condition is frequently done. Recessing and edge routing is also performed on expanded or full-open core.

When core shaping is difficult because of complicated contours or the part is very large, supported core machining may be the answer. In one instance, expanded core is placed in a container of water which is then frozen. When required, the block of core and ice is transferred to the carving lathe. A wood master airfoil is positioned and rotated in unison with the work. High-speed tungsten carbide saws make the full cut in one pass. Resins are also used to support cores during machining, especially for small complex components.

Manufacture of facings for flat or simple curved honeycomb sandwich applications is straightforward if the handling of large thin sheets of material can be so considered. Routine laminating and lay-up procedures are used for the plastic impregnated-type facings. A critical honeycomb application may require precise components and tooling, much intricate hand fitting and expensive bonding fixtures. If the facings



Radiograph of Brazed Honeycomb Indicates Kinds of Possible Flaws

are of 2024 or 7075 and contoured, great care is necessary to insure good lay-up in the heat treated condition.

In steel honeycomb sandwich, the problems of facing fabrication are similar but apparently far more difficult. This is due in part to the thinner sheet metal used and to the fact that steel is inherently tougher to form. Furthermore, all-metal sandwich components require dimensional precision that sets new standards of quality. Whereas aluminum sandwich components can be produced with mating tolerances in the range of 0.005 to 0.010 in., high-temperature steel structural sandwich necessitates mating tolerances within about 0.003 in. The same degree of precision is required of inserts, edge attachment lap strips and reinforcing pads.

Both adhesive-bonded and all-metal types of sandwich require essentially the same lay-up or assembly procedures. Adhesive is generally applied liberally to top and bottom of the core as well as the facing sheets. In fact, both surfaces of every joint are thoroughly primed or coated. Frequently, unsupported tapes of adhesive film are used. Putty-type resins serve to fill sizable gaps and to join core segments together.

To assist in bonding of aluminum facings to core, adhesive-soaked glass fabric or open-mesh cloth (scrim cloth) is used. This resilient filler seems to take up minor dimensional discrepancies and to assure complete bonding. In addition, the glass fabric or scrim increases the peel strength and fatigue strength of the sandwich.

Either welding or brazing must be used to assemble high-temperature sandwiches. Resistance welding is being used by a number of producers but very little information is available concerning either the processing or the properties of the assemblies. Wire screen or mat is incorporated between core and facing by some fabricators to assure continuity of the welds. The insert also increases the joint strength. The core walls are plated with aluminum, silver or copper to lower their electrical resistance. This minimizes over-all core heating and the possibility of collapse during welding.

Brazing was the first successful means developed to produce high-strength high-temperature all-metal honeycomb sandwich, and it is likely that welding and brazing will be used in complementary fashion to fabricate all-metal sandwich for future needs. The brazing material is placed on the core walls or on one or both facings. At the brazing temperature, the alloy fuses and by surface tension and capillary forces, penetrates every joint. A major advantage of brazing is that radiographic inspection may be used to detect any defects in the joint.

The cost of brazing is high because dimensional tolerances are narrow and the core must be free of burrs. Even a minute burr will interfere with the flow of brazing material or make the cell unsymmetrical by leaning. It will also necessitate additional brazing alloy to accommodate the wider joint lap. A panel with ⅛-in. cells, 1 in. thick, is calculated to contain 1/5 mile of capillary braze joint per sq.ft.

Aircraft and missiles are using virtually all the available high-temperature sandwich but some commercial usage is expected. Possible applications include those where a lightweight high-strength structure with either coolant or heat flow through the core is required. Large-scale use of all-metal honeycomb is bound to decrease its manufacturing cost and increase the number of economically feasible applications.

Metal Whiskers

*By G. W. SEARS and S. S. BRENNER**

The strength of small metal whiskers is close to the theoretical value; for example, the tensile strength of iron is 1,900,000 psi. Unfortunately, the strength decreases as the size increases although many other of the unusual properties are retained. (M 26, N 2)

In recent tensile tests on pure annealed iron at the General Electric Research Laboratory, a specimen withstood 1,900,000 psi. before fracture. Equally remarkable by comparison to the behavior of ordinary tensile specimens was the absence of plastic deformation and work hardening. The test was performed on an iron whisker 0.000,000,004 sq.in. in cross section and 0.1 in. in length. The applied load, which was only 0.1 oz., produced an elastic strain of almost 5%. The test clearly showed that the elastic strengths calculated for perfect crystals can be attained for actual crystals.

For almost 40 years it has been realized that the strengths of real crystals are 100 to 1000-fold less than the theoretical strengths of perfect crystals. One of two basic assumptions might be made to account for the large discrepancy between the theoretical and measured strengths. Either the atomic theory of cohesive strength of crystals is grossly wrong or the assumption of crystal perfection is invalid. Since no serious doubt has been cast on cohesion theory, all serious efforts to rationalize the mechanical behavior of real crystals have involved a postulate of some sort of defect structure. The concept of dislocations arose to account for plastic flow at small stresses. The importance of the dislocation theory lies in its applicability to a tremendous number of solid-state phenomena, including diffusion, precipitation, polygonization and crystal growth. In many properties crystal behavior is characteristic of the defect structure rather than the perfect crystal structure.

Fortunately, the regularity of a crystal imposes constraints upon the number of ways a crystal can go wrong. Thus there are only two basic types of dislocations, edge dislocations (Fig. 1) and screw dislocations (Fig. 2).

One of the more important predictions of dislocation theory is that a crystal free from dislocations or containing very few dislocations should have the very high strength predicted by cohesion theory for perfect crystals. The very fact that whiskers are very strong suggests that they are nearly dislocation-free. However, dislocation theory also predicts some ways that dislocations can be locked into position so the high strengths observed only demonstrate that the strengths calculated for perfect crystals can be attained on actual tensile specimens.

With the large-scale use of electronic devices by the military establishment during World War II, it became necessary to make electronic units more and more compact. This led to a very surprising difficulty. Frequently, very fine whiskers of tin or cadmium grew from the protective plating on the component parts, and the equipment was put out of operation when the whiskers acted as short circuits. Their occurrence in thermostats of electric blankets was described in the November 1955 issue of *Metal Progress*.

Galt and Herring of Bell Telephone Laboratories reasoned that tin whiskers might be free of dislocations by virtue of their small size, and in 1952 they demonstrated that tin whiskers can support elastic strains in bending of about 2%. This was the first example of crystals which exhibited the elastic behavior postulated for perfect crystals.

Since the experiment of Galt and Herring, a large variety of metal whiskers has been grown by several methods. The tremendous strength of some of these whiskers has been demonstrated even more strikingly by recent tensile tests where the stress on the whiskers was much more than in a bend test. The strength of 1,900,000 psi. for iron is believed to be the highest tensile stress ever supported by metal. Maximum tensile strengths reported for other metallic

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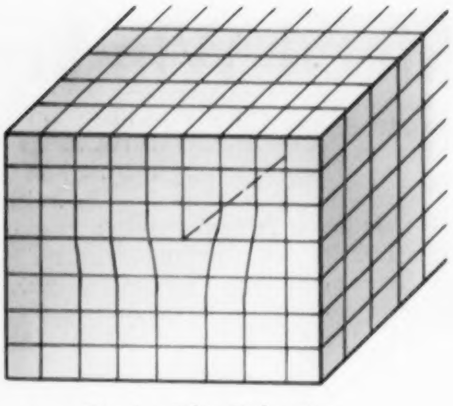


Fig. 1 – Edge Dislocation

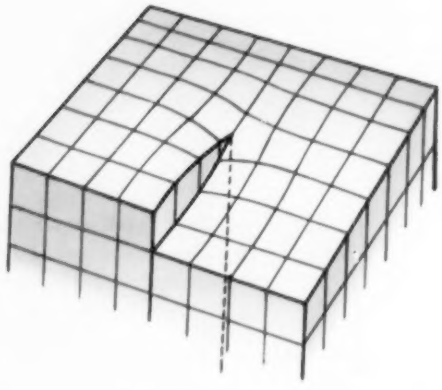


Fig. 2 – Screw Dislocation

whiskers are 555,000 psi. for silicon, 440,000 for copper, 250,000 for silver and 55,000 for zinc.

The tensile tests on iron, copper and silver were performed in the apparatus shown in Fig. 3. The whisker, mounted at one end to a float containing a magnet, was stressed by applying a current to a solenoid which pulled the float toward the center of the solenoid. The force exerted by the solenoid was calibrated with the aid of a balance. In a few instances the strain as well as the stress has been measured by observing the change in distance between two fiducial marks on the whisker. The stress-strain diagram of a superstrong iron whisker is shown in Fig. 4. The whisker was about 0.000,06 in. in diameter and 0.1 in. in length. The strain, reported to be entirely elastic, is proportional to the stress only up to 2%. When the whisker finally fractured after having been stretched close to 5% of its original length, sufficient elastic energy was released to cause it to snap back and wrap itself around as shown in Fig. 5.

Whiskers can be obtained in a number of ways. The tin whiskers used by Galt and Herring, as well as zinc and cadmium whiskers, grow spontaneously at room temperature from coatings of these metals. The coatings can be applied by electrodeposition, vapor deposition or hot dipping.

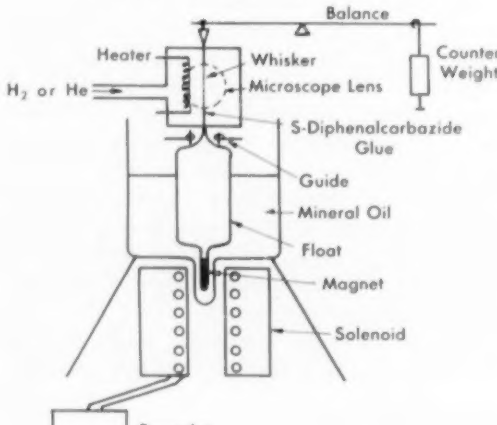
The spontaneous growth of the whiskers requires several weeks or months but can be accelerated as much as 10,000 times by the application of pressure to the coating. The whiskers, about 0.000,01 in. in diameter, grow by the addition of material at their base and attain lengths up to ¼ in. In addition to straight whiskers, many are bent and kinked.

Another method of growing whiskers is the condensation of supersaturated metal vapor at a suitable temperature. The first metal grown in the shape of whiskers by this method was mercury which had been evaporated at – 22° F. and condensed on a pyrex surface at – 81.4° F. Zinc whiskers grown by this method at 660° F. and silicon whiskers grown at 2280° F. sometimes attain lengths in excess of ½ in. One silicon whisker grown by condensation supported a bending stress of 725,000 psi.

A third method of whisker growth is the chemical reduction of metal salts such as the halides. The halide vapor or a boat filled with the solid halide is brought into the hot furnace where it decomposes or is reduced by hydrogen or zinc. Iron whiskers grown by this method are shown in Fig. 6. Note that some are twisted and kinked.

A large variety of whiskers has been grown by this method. Whereas iron, copper, silver and silicon whiskers grow in great profusion, the number of gold and nickel whiskers is very small. Copper whiskers appear to grow by the addition of material at their tips.

Fig. 3 – Apparatus for Measuring Tensile Strength of Whiskers



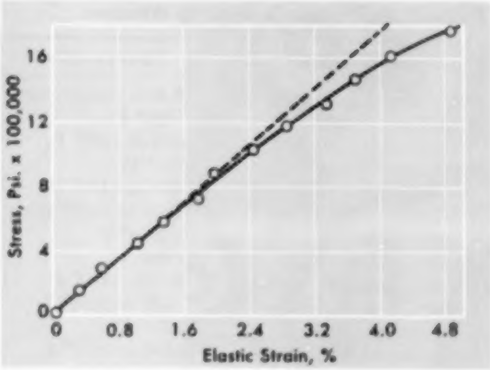


Fig. 4 – Stress-Strain Curve of an Iron Whisker

Fig. 5 – Appearance of Iron Whisker After Fracture

Fig. 6 – Iron Whiskers Grown by the Reduction of Iron Bromide at 1330° F. 8 ×

A fourth method of whisker growth is electrodeposition. Most work on the growth of metals such as silver or copper in the form of thin single-crystal filaments has been done by German and Russian workers. It has been found that the use of very small cathodes, high current densities and inhibitors such as gelatin or dextrose promote the filamentary growth. Very little has been reported concerning the size and properties of the filaments or whiskers. Methods used for making whiskers of the various metals are summarized in Table I.

It has been possible to elaborate a detailed growth mechanism for the direct vapor deposition process. In 1878, Willard Gibbs postulated that growth of a perfect crystal could only occur by a mechanism of two-dimensional nucleation. He pointed out that growth could occur at an appreciable rate for supersaturations above a critical value. In 1931, Volmer and Schultze measured the growth rate versus supersaturation for several crystals. They found that growth continued almost to zero supersaturation. The discrepancy between the experimental results and Gibbs's prediction was resolved by Frank in 1949.

Frank commented that since real crystals are imperfect, repeated surface nucleation as proposed by Gibbs may not be necessary for continued growth. Frank proposed that the intersection of a screw dislocation with the surface created a permanent step on the surface at which growth could proceed. As growth occurred the step would rotate around the fixed screw axis and generate a spiral growth marking. Growth by the screw dislocation could occur at very low supersaturations in agreement with the results of Volmer and Schultze.

Immediately after Frank's proposal was made,

Table I – Methods Used to Grow Metal Whiskers

Metal	Method of Growth	Temperature
Cadmium	From plated coatings	Room temperature
Cobalt	Reduction of bromide	1290° F.
Copper	Reduction of CuI_2 and $CuCl_2$	800 to 1380° F.
Germanium	Decomposition of GeI_4	930° F.
Gold	Decomposition of chloride	460 to 1470° F.
Iron	Reduction of $FeCl_2$ and $FeBr_2$	1020 to 1470° F.
Mercury	Condensation	−81.4° F.
Nickel	Reduction of bromide	1290° F.
Platinum	Decomposition of chloride	460 to 1470° F.
Silicon	Reduction of $SiCl_4$	1470 to 1830° F.
Silicon	Condensation	2280° F.
Silver	Reduction of AgCl	1290 to 1470° F.
Silver	Condensation	1560° F.
Tin	From plated coatings	Room temperature
Zinc	From plated coatings	Room temperature
Zinc	Condensation	660° F.

experimental confirmation in the form of observed spirals on a wide variety of crystals was reported. With CdI_2 platelets growing from aqueous solution, it was possible to observe the spiral growth process in action.

To account for the whisker growth from the vapor phase, it is sufficient to assume a parent crystallite having a single screw dislocation. At low supersaturations such a crystallite should grow in the direction of the screw axis at constant cross section. The growth by this mechanism proceeds by a tip growth process. The resultant whisker bears a single-axial screw dislocation and should have the theoretical elastic strength.

Of the other processes which have been used to produce whiskers, it is possible to make a basic differentiation. Does the growth occur by addition to the tip or to the base? Any basal growth process, such as the growth of tin whiskers spontaneously or by application of pressure, patently cannot occur by the growth mechanism proposed for vapor deposition. If growth occurs at the tip as in copper whiskers prepared by chemical reduction, the uniaxial screw mechanism may offer a reasonable explanation of the growth behavior.

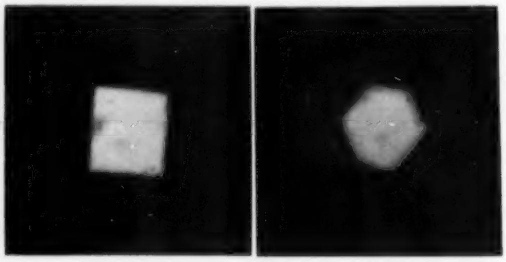


Fig. 7 – Cross Sections of Two Iron Whiskers. 2000 ×

Most of the short straight whiskers are single crystals with their axes parallel to a major crystallographic direction such as [111], [110] and [100]. Some of the kinks in the distorted whiskers appear to be twins. The cross sections of the whiskers are usually polygonal as shown in Fig. 7. There is, however, considerable variation in the cross-sectional shape of whiskers of the same metal. Heating at temperatures near the melting point causes the whisker edges to become rounded.

Many of the whiskers have highly reflective surfaces, some of which appear perfectly smooth at magnifications as high as 40,000 ×.

Spectrographic analyses of copper whiskers indicated the presence of silver in a concentration of about 30 ppm. The concentrations of other elements commonly encountered in copper were below the sensitivity of the spectrograph. Purification of the salt prior to its reduction reduced the silver content in the whiskers below a detectable amount. The purity of other metal whiskers has not been established.

At present the mechanical properties of whiskers are of greatest interest but there are indications that whiskers may possess other properties quite as remarkable. For instance, if a copper whisker is bent beyond the elastic limit until permanent deformation occurs, the whisker will recover its original shape if subsequently annealed at a high temperature. A copper whisker which was straight initially was bent until it kinked, and then annealed at 1855° F. It recovered its original shape after 40 min. The deformation and the subsequent anneal did not impair its strength.

Although the mechanism of deformation or kinking of a whisker is not yet understood, it seems reasonable to assume that edge dislocations are introduced into the whisker when the elastic limit is exceeded. The high-temperature recovery of the copper whisker implies that these dislocations can again migrate out of the crystal at sufficiently high temperatures. The migration is presumably possible because of the absence or near-absence of dislocations in the original

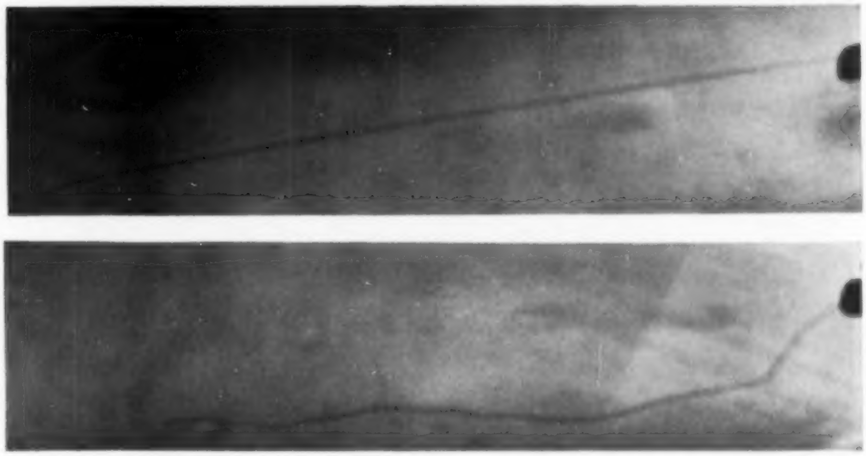


Fig. 8 — Transformation of Iron Whisker From the Alpha to the Gamma Phase Causes Severe Distortion

whisker. In bulk crystals, the thermal motion of dislocations is hindered by the interlocking of the dislocations.

The transformation of the iron whiskers from alpha to the gamma phase is another interesting phenomenon. The transformation is accompanied by severe distortion of the whisker as is illustrated in Fig. 8. Transformation occurs at intervals along the whiskers, and the boundary of the alpha region can sometimes be observed to travel along the whisker. It is characteristic of a nucleation and growth process. The nucleation of the gamma phase is assumed to be more difficult in the whiskers because of the absence of dislocations. Superheating of the alpha phase is frequently required to initiate the transformation in a reasonable time. The distortion which occurs upon transformation is probably due to the volume change of the two phases.

One of the greatest hindrances to many applications is the extremely small size of the whiskers. Although they can be grown several inches long and 0.010 in. thick, the larger whiskers are much weaker than the finer whiskers. The decrease in the strength is believed to be due to the accidental formation of structural defects as the whisker grows. A major problem is to find means of preventing the formation of these defects either by modifying existing growth techniques or by developing new techniques.

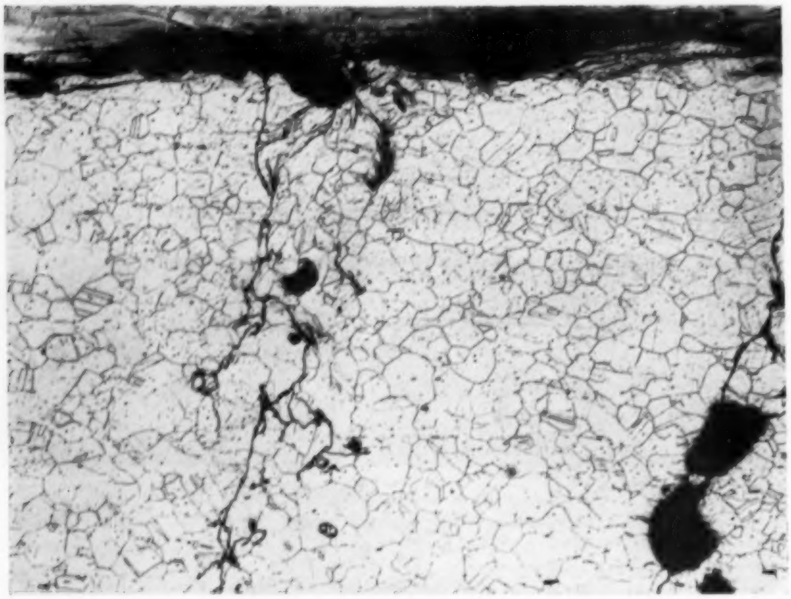
The research applications of whiskers are numerous and several practical applications may result from them. For instance, whiskers may become useful in experiments requiring relatively pure single crystals of known orientations. The preparation of single crystals by ordinary techniques, especially of iron, is considerably more difficult.

The field of magnetism will undoubtedly benefit greatly from studies on iron whiskers. The orientation of most of the iron whiskers is such that their axes are parallel to the direction of easy magnetization. They are small enough to contain only a few domains, and it may be possible to study the motion of domain walls as the magnetic field is reversed.

Experiments making use of the great strength of the whiskers may produce interesting results. Several per cent of elastic strain has a profound effect on the metal lattice, changing its crystallographic symmetry and probably affecting its electrical resistance, magnetic properties and chemical properties. If whiskers are free of dislocations they may be useful in studies involving diffusion, phase transformation, precipitation and other kinetic processes which are greatly influenced by structural defects. The residual resistivity at low temperatures due to defects may be determinable by using whiskers.

Surface reactions such as adsorbtion, evaporation and catalysis are greatly influenced by surface structure and smoothness. The surfaces of whiskers may be perfect and atomically smooth so that these reactions may be considerably altered.

The discovery of whiskers has demonstrated that the theoretically calculated strengths for perfect crystals may actually be attained. Future studies will undoubtedly extend our understanding of solid-state behavior.



Section Taken From Corroded Tank, Showing Branched Transcrystalline Cracks Typical of Stress-Corrosion. 100 ×

The Case of the Chloride Ions

*By MARJORIE R. HYSLOP**

Detective Joe Thursday, assigned to solve a tank failure, tracks down and identifies the culprit as stress-corrosion, and then shows how to safeguard valuable property in the future. (R 1, SS)

It was a fine Friday morning in spring, and Joe Thursday, metallurgical detective, surveyed his desk and decided that for once maybe he could forget about the job and look forward to a Saturday outing with his wife and kids. These agreeable thoughts were interrupted by the ring of the telephone, and as soon as he picked up the receiver and heard his boss's voice Joe knew that he had only been daydreaming again.

"Joe, I just got a call from our field man in Ohio," said the boss, "and the boys at Stuff and Such Chemical Corp. have just reported a bad

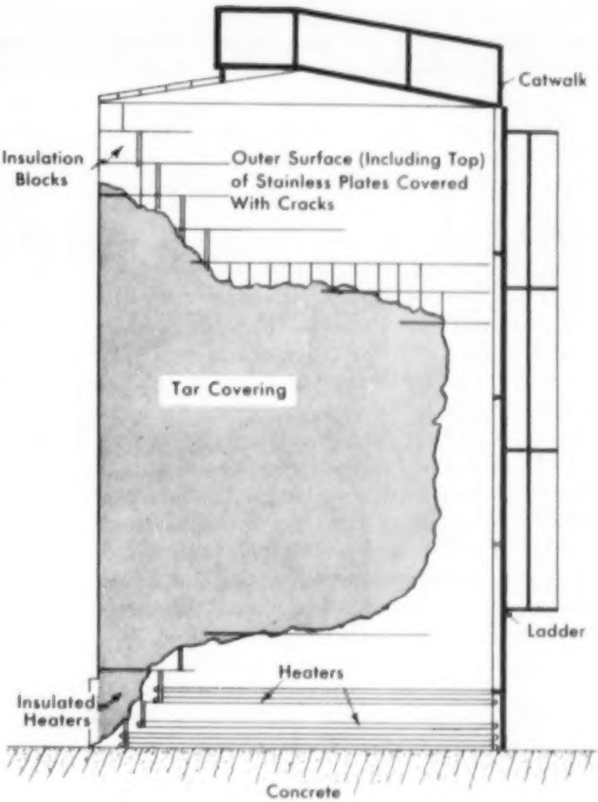
*Managing Editor, *Metal Progress*. Based on material provided by the research laboratories of Armco Steel Corp. and by W. F. McFee, product information service.

tank failure. Sorry to spoil your weekend but if we want to keep on selling them steel, maybe you'd better highball right down there."

Joe, being a conscientious metallurgist and a dedicated detective, wasn't downhearted for long, especially when he found he could make immediate connections for Middle City, and perhaps even get back that evening.

Arriving at Stuff and Such, Joe was ushered into the plant manager's office, and after the introductions and an account of how this blankety-blank tank suddenly started leaking hot chemical all over the yard, he asked to see it. It was an outside storage tank, 12 ft. in diameter and 21 ft. high, made of ¼-in. Type 304 stainless steel plates, and contained – or was supposed to contain – maleic anhydride, certainly not a chemical expected to have much effect on stainless steel.

Joe saw that there were two coil heaters around the outside of the tank near the botttom, and was told that the anhydride was kept hot – 160 to 195° F. The tank had been completely insulated on the outside with 2-in. glass blocks, and the whole thing plastered with hot tar. Some of the blocks had already been torn off by workmen looking for the leaks and Joe arranged to have enough of the stainless steel surface exposed so he could make a fair appraisal of the entire outside.



Sketch of Stainless Steel Maleic Anhydride Tank That Failed

While this was being done he asked a few questions and learned that the tank was approximately a year old. About three months before the tank started to leak, one of the heaters had to be repaired. No one could tell him how long the heater had been leaking steam under the insulation. He also learned that a workman had once accidentally emptied the tank with the vent closed; the top had collapsed and had been repaired.

Joe then examined the tank carefully. The interior was in excellent condition; markings placed on the plates during fabrication were still visible. No cracking nor corrosion products could be seen on the inside. "That", said Joe to himself, "eliminates the maleic anhydride".

The outside of the tank told a different story! It seemed to be entirely covered with fine cracks. Three definite leaks were located. Light rust was found just above the top of the heaters, and under the heaters Joe saw large patches of loose scale. The iron ladder was in good condition but the supports were severely corroded where they passed through the insulation. The surface cracks toward the top of the tank appeared to fall into a pattern of vertical lines about 6 in. apart. Joe picked up one of the glass blocks and found it was just 6 in. wide.

By this time Joe thought he had some pretty good clues, but he still had one more question. "What about atmospheric contamination?"

The plant manager admitted that they frequently exhausted sulphur chloride to the atmosphere and occasionally free chlorine. He also said that hydrogen sulphide from another chemical plant nearby could occasionally be smelled in the air.

Joe made a few more scribbles in his notebook and stuffed it back in his pocket. "Now", he said, "how about cutting me off a small piece of the tank up toward the top where there are some cracks? I'll just take this piece of brick with me, and if you have some sort of envelope handy

let's scrape off a little of these corrosion products too. I have a pretty good hunch what the trouble is but we'll have to make some lab tests. I'll write you a complete report next week."

The mollified plant manager thanked him and Joe headed for home, stopping to put in a long-distance call to tell his wife to get the picnic basket in readiness.

Early Monday morning Detective Thursday fished the piece of steel, the piece of glass block and the envelope of scrappings out of his briefcase and went to work. The analysts found that the piece of Type 304 stainless steel plate contained 18.59% chromium, 9.47% nickel and 0.054% carbon. Quite normal. He had the block and the corrosion products analyzed qualitatively for chlorides and found appreciable amounts in the block and small amounts in the corrosion products. Leachings from the insulation were tested for acidity and gave a pH value of 3.3.

In the metallographic laboratory Joe found that his preliminary suspicions were confirmed. Structure of the sample was normal for Type 304 plate and grain size was A.S.T.M. No. 6 to 8. Hardness was Rockwell B-80. The cracks visible to the eye showed up under the microscope as severe branched transcrystalline cracking, typical of stress-corrosion.

With the evidence before him and the train of events fitted into a mental picture, Joe started to write his report. He hadn't gone far when he picked up the intercom and called his boss. "Bill," he said, "I think I'd better run down to Middle City again and talk to them about this busted tank. I know what caused the trouble but they'll have to give us some help to prevent more failures and I'm not sure just what to recommend." With the O.K. from his boss he again packed his briefcase.

Back in Middle City, Joe spread the evidence on the plant manager's desk and launched into an attempt to explain stress-corrosion. "It can happen," he said, "when austenitic stainless steel is stressed in tension (such as in the fabrication of this large tank) and then exposed to relatively mild corrodents – in this instance, chlorides from the insulation." He hastened to say that, considering the tonnage of stainless used in the chemical industry, this type of failure is relatively rare.

"Well, why did it happen to us?" asked the plant manager.

"Probably it wasn't so much the amount of chloride ions leached out of the insulation by the steam leak as the fact that they are concentrated where the water in the leachings evaporates. Any breaks in the tar coat would also let rain water seep in.

"I think that temperature is another factor in your trouble," he continued. "Not only did the heat of the tank help concentrate the chloride ions, but we believe that the higher the temperature the less chlorides needed for cracking."

"I follow you," said the P. M., "but I remember you asked about atmospheric contamination. Does that have anything to do with it?"

"Possibly," said Joe. "Certainly chlorine could be absorbed by rain water. But I do think most of it came from the insulation itself. Then there's another minor point. The leachings that we tested from the insulation were quite acid, and acid environments considerably shorten the time require to develop cracking."

"This is all pretty discouraging," said the P. M., "unless you can tell us how we're going to avoid this type of thing in the future."

"I think we can," said Joe, "and maybe you'll have some ideas of your own. The best thing would be to get rid of the residual stresses in the bent steel plates by heat treatment. Whether there is a furnace nearby that can take a tank the size of yours is another matter. Why don't you talk to your tank fabricators?"

"We'll try that, but how about a different type of insulation that wouldn't leach out these chloride ions?"

"That's another thing I was going to suggest," Joe said. "The best place to go for that is the Bumbrick Co. They've done a lot of work along this line. The next thing I'd recommend is to paint the tank before insulating it. Many air-drying enamels will do the trick. A lot of paint companies make them but I think probably the Dripless Paint Co. is your best source."

"You know I've been thinking about something else," said the P. M. "Maybe we could change our tank design a little. If we would extend the top of the tank out over the sides something like a roof," sketching on a scratch pad, "it would form a drip edge past the side insulation. Wouldn't that be an extra factor of safety?"

"It would," said Joe.

"Then we might even do something about the heater design, so if it sprang a leak the steam wouldn't get inside the bricks. Besides it would be much easier to inspect and maintain."

"Well, I can see you don't need me anymore," said Joe, "and I'll give you odds you'll have no trouble with your new tank."

"Sorry, no bets," said the plant manager with a grin.

Explosions of Titanium and Fuming Nitric Acid Mixtures

*By L. L. GILBERT and C. W. FUNK**

Serious accidents have occurred when titanium alloys were exposed to the fuming nitric acid used in rocket engines. The probability of a pyrophoric reaction depends upon the amount of water and NO_2 in the acid. (R 6, Ti)

Titanium alloys are ideal structural materials for chemical and liquid rocket engine systems using fuming nitric acid because of their light weight, good mechanical properties and excellent corrosion resistance. Unfortunately, several serious accidents have occurred when commercial alloys reacted violently with fuming nitric acid.

In one of the first accidents some test specimens of an 8% manganese alloy (RC-130 A) reacted pyrophorically with the fuming nitric acid in which it had been immersed. A technician was reported to have been burned by the explosion and the subsequent spray of acid. The specimens were attacked and pitted and reduced to spongy masses in localized spots. There was also some evidence of fused titanium metal. The acid was analyzed by Aerojet and found to contain 26% dissolved NO_2 and 0.57% water.

Since this alloy contained manganese, it was assumed that the manganese was contributing to the pyrophoric reaction. However, a few months later, in December 1953, a second serious accident occurred at another laboratory in which only unalloyed titanium (RS-55 and Ti-75 A) samples were involved. The titanium appeared to have been attacked intergranularly and was discolored. The sheared edges of some specimens were melted in localized areas. The titanium that was most contaminated with carbon and iron was most severely corroded. The acid contained 20% or more NO_2 and 0.42 to 0.57% water.

Four types of fuming nitric acid defined by military specifications are listed in the table on p. 94. Conventional corrosion tests performed on commercially pure titanium and the alloys available in 1953 indicated excellent resistance to the corrosive attack of these acids. Corrosion rates of less than 0.001 in. per year were confirmed by various investigators. Galvanic corrosion test results in acids containing less than 1% NO_2 with titanium coupled to various stainless steels indicated excellent compatibility. Simulated service tests on small tanks showed no weight loss after one month exposure to fuming nitric acid at 160° F. and valve shafts were used for one year in field tests.

Stress-corrosion cracking of commercially pure titanium in fuming nitric acid containing 20% NO_2 was first reported by G. C. Kiefer and W. W. Harple in the June 1953 issue of *Metal Progress.* They indicated that bromide ion additions inhibited stress-corrosion. No evidence of stress-corrosion was found in any tests performed with fuming nitric acid containing less than 16% NO_2.

With the stress-corrosion and pyrophoric phenomena still unexplained, titanium-base alloys could not be considered reliable for contact with fuming nitric acid. To provide information as to the scope of the problem and the significance of the possible variables causing the pyrophoric reaction, Aerojet-General Corp. initiated a limited test program to reproduce the reaction and evaluate the significance of certain variables. This program was carried on under the sponsor-

*Head of the Materials Dept. and Head of the Metallurgy Section, respectively, Liquid Engine Div., Aerojet-General Corp., Azusa, Calif. This article is based on results of an investigation supported by Wright Air Development Center under U.S.A.F. Contract 33(038) 20798.

ship of the Materials Laboratory of Wright Air Development Center, with titanium sheet materials supplied by the Bureau of Mines.

Safe procedures were established as a dominant principle for the testing program in view of the history of serious accidents. Since the pyrophoric reaction had apparently been initiated by shock, the qualitative test apparatus was set up to duplicate this effect. Reliability of the apparatus required an actuating force to cause impact, a simple trigger mechanism and a suitable means of observing the reaction. An apparatus was arranged to be remotely operated in a concrete test bay by personnel behind a barrier observing the reaction by means of a mirror system. Gravity was used as an actuating force to cause impact and a simple pin was used as a pinion trigger, as in Fig. 1.

Chemical Composition of Fuming Nitric Acids (Per Cent by Weight)

Type	Nitrogen Dioxide	Water	Nitric Acid	Total Solids	Military Specifications
I	0-0.5	2 max.	97.5 min.	0.1 max.	MIL-N-7254 B
II	6.5-7.25	2.5 max.	90.25-93.5	0.1 max.	MIL-N-7254 A*
III	13-15	2.0-3.0	82.0 -85.0	0.1 max.	MIL-N-7254 B
	14-16	2.5-3.5	80.5 -83.5	0.1 max.	MIL-N-7254 A*
IV	21-23	2-3	74.0 -77.0	0.1 max.	MIL-N-7254 A*

*Obsolete composition by revised specification.

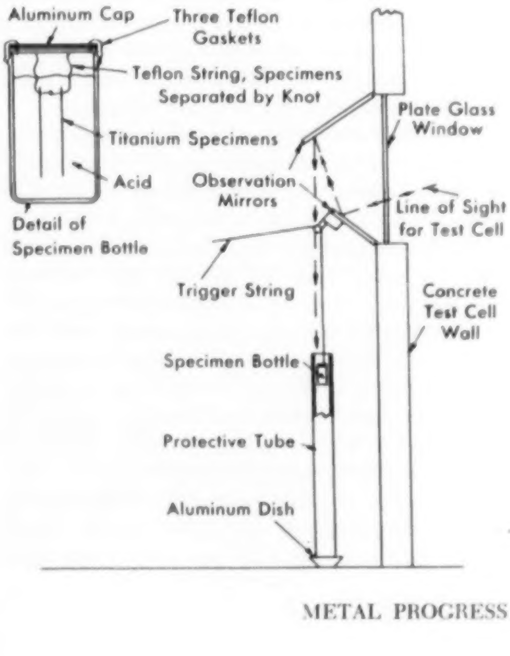
Four-ounce glass capsules capped with screw-type aluminum lids, isolated from the acid system by double Teflon gaskets, were used to contain the acid and the metal coupons. The coupons were completely immersed in acid. Loaded capsules were suspended on individual aluminum wires. The wires were released by a single aluminum pin that could be removed by a trigger string at the observation station behind the concrete bulkhead. Each capsule was suspended over a 2.75-in. diameter, 32-in. long aluminum tube to guide the free-falling container to the impact point. This guide tube also limited the distribution of the reactants after the drop. The drop tube was positioned over a 4-in. diameter aluminum tray that was used to collect the residual acid after the reaction. Each collection tray rested on 0.5-in. steel plate to assure sufficient impact inertia to fracture the glass capsule. The drop tubes were carefully aligned in a vertical position so the line of sight through the mirror system would be along the axis of the drop tube and the reaction at the base of the tube could be observed. Although the specimens were masked by the capsule cover, the reaction was of sufficient magnitude to be seen.

The pyrophoric reaction was recorded by color motion pictures at a speed of 64 frames per sec. The camera was positioned by sighting through the mirror system down the axis of the drop tube. The number of frames recording the flash of the reaction gave a qualitative measure of the duration and magnitude of the reaction.

The samples were $0.060 \times 1 \times 2$ in., sheared from commercially pure Type RS-55 and iodide titanium sheet. Coupons were used in either the 30% reduced or vacuum annealed condition. Stress was intentionally introduced by shearing the edges immediately prior to acid exposure to introduce the minimum degree of surface passivity and a greater probability of reaction. Duplicate coupons were placed in each capsule to induce friction between metal surfaces during impact. Both the newly sheared edges and the pairing of specimens were eliminated after it had been demonstrated that these factors were not required for initiation of the reaction.

Each lot of acid used in the tests was analyzed for its HNO_3 content, total NO_2, water and dissolved solids. The total HNO_3 content of the acid was established by the back titration of an

Fig. 1 – Apparatus Used to Evaluate Explosiveness of Mixtures of Titanium and Fuming Nitric Acid



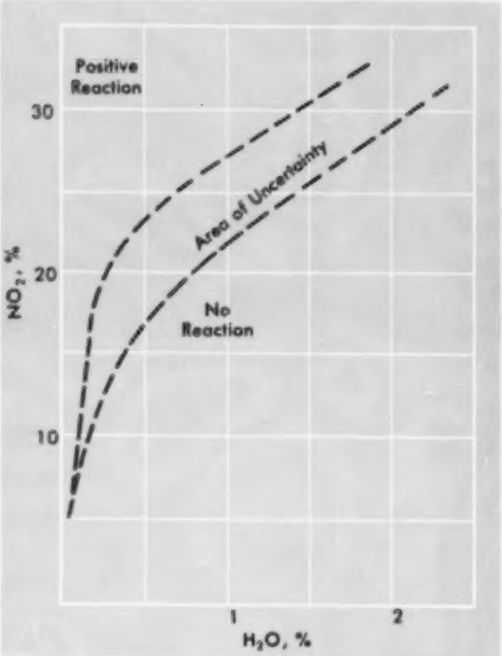


Fig. 2 – Effect of Acid Composition on the Pyrophoric Reaction With Titanium

excess addition of KOH using a phenolphthalein indicator. The NO_2 content was determined by back titration with ferrous ammonium sulphate of excess ceric sulphate. Dissolved solids were recovered by evaporation to dryness. The amount of free water in the acid was estimated by the infrared absorption of the acid measured by a modified Beckman Model D 4 spectrophotometer. Although this method was not calibrated for fuming nitric acid with an NO_2 content above 6%, a correction factor was used which gave a precision of 0.1%, considered to be adequate for the purpose of these tests.

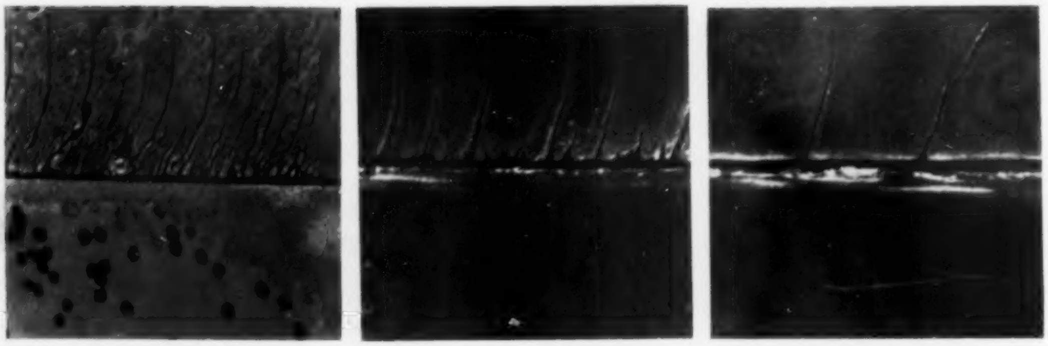
Since the water content of the acid was considered a significant variable, synthetic acid was used to control water content. Synthetic acid lots were distilled and then dehydrated by passing the acid through a tower of P_2O_5 dessicant. The Harris method of water analysis frequently showed such anhydrous acids to have "negative water". Negative water is that percent of water which would have to be added to a N_2O_5 system for zero water equivalency. The use of synthetic acids simplified the blending of a specific acid composition and eliminated uncontrollable variables such as the effect of dissolved solid impurities in the acids which would be capable of altering the available free water content.

The pyrophoric reaction obtained was positive and emphatic. A brilliant flash of flame was accompanied by a loud report. Scattering of acid and glass fragments resulted from the extreme heat and rate of reaction. The potency of the reaction appeared to vary in different tests, possibly because of the availability of the reactants resulting from corrosion of titanium. The surface appearance of each titanium coupon that produced a pyrophoric reaction was altered by either discoloration, oxidation or localized cracking of the metal, particularly along newly sheared edges. Acid that reacted with the metal contained a flocculent precipitate after the reaction. The acids were clear of such a precipitate upon loading the capsule and after exposure of the metal to acid prior to detonation. The intensity of the heat of reaction was demonstrated by actual droplets of fused metal and a metallic deposit fused on the glass chips of the original capsule.

Motion pictures provided an estimate of the flash interval of the reaction ranging from 0.01 to 0.1 sec. These films indicated a correlation of reaction intensity to the water content of the acid.

The significant feature of each reaction was the relatively anhydrous condition of the acid to which the metal was exposed. Only acids containing less than 1.34% water were capable of the pyrophoric reaction. The influence of acid analysis is shown in Fig. 2, which illustrates the acid compositions capable of producing the reaction under the conditions of these limited tests. Although there is an area of uncertainty caused by problems of acid analysis and dissimilar test conditions, a demarcation appeared between acid compositions capable of producing the reaction and those not capable of producing the reaction under the given conditions. Tests of acids with lower NO_2 contents show a positive reaction at the 6% NO_2 level, but no reaction at 3%. The highest water content of the acid producing a reaction was 1.34% with 24% NO_2.

The demarcation zone for positive reaction was established by plotting the analysis capable of initiating the pyrophoric reaction. Reasonable credence as to the accuracy of the curve is indicated by positive reaction of 22 out of 24 tests with initial acid composition in the positive area of the curve. Two tests did not react, possibly due to water buildup. The water content of one solution increased five-fold from 0.57% after a three-day exposure at room temperature with and without the presence of titanium. This indicates how extremely anhydrous fuming



0.34% H_2O *0.57% H_2O* *1.1% H_2O*

Fig. 3 – Corrosion Cracking on Top (Above) and Bottom (Below) of Sheared Edges of Titanium Samples After Exposure to Fuming Nitric Acid. 6 ×

nitric acid dissociates to higher water contents.

An analysis of acid after the drop tests revealed a deterioration of the acid during exposure. The water content increased and the NO_2 content decreased. Comparison of these results with test blanks using no metal showed that these effects were caused by leakage of the containers combined with deterioration during transfer from trays to acid sampling flasks after the completion of the reaction.

All coupons that exhibited a pyrophoric reaction revealed some form of corrosion. Cracking was common along newly sheared edges. An oxidation discoloration was also evident either in spots or uniformly distributed all over the surface. The surface of titanium exposed to acid of higher water content for as long as seven days was unchanged. Some of these specimens are shown in Fig. 3.

The pyrophoric reaction was also observed when iodide titanium was exposed for ten days to acid with 0.57% water. Specific tests on single and unsheared coupons in the vacuum annealed condition, as well as those which had been 30% cold reduced, produced positive pyrophoric reactions. An attempt to reproduce the reaction upon exposure to vapor alone was negative, possibly because of the inability to contain or control the analysis of the vapor. The positive reaction of synthetic acids shows that the dissolved solids neither assist nor hinder the reaction.

Although this test program was of a preliminary nature, certain conclusions are justified:

1. Fuming nitric acid with less than 1.34% water and more than 6% NO_2 is capable of sensitizing titanium-base alloys, causing violent pyrophoric reactions initiated by shock or other means of excitation.

2. Titanium exhibits corrosion prior to the pyrophoric reaction.

3. Conditions which are not required for initiating the pyrophoric reaction determined are: *(a)* friction between two metal coupons, *(b)* newly sheared edges, *(c)* prior cold work, and *(d)* alloy content. This should not be construed to mean that these conditions do not affect the intensity of the reaction but they do not appear to be the basis for its initiation.

Although the authors recognize the inadequacy of the data to formulate an explanation of the mechanism of the pyrophoric reaction, the following hypothesis is presented to encourage discussion and further investigation.

1. The passive oxide film of inherently corrosion resistant titanium is apparently deteriorated or penetrated by ions produced through dissociation of nitric acid resulting from a lower water content.

2. Upon breakdown of the passive film, intimate contact of the strongly oxidizing nitric acid is capable of attacking the reactive titanium ions, particularly when the metal is stressed.

3. The attack becomes intergranular, particularly at the alpha-beta phase interfaces, to produce finely divided separate grains of titanium metal.

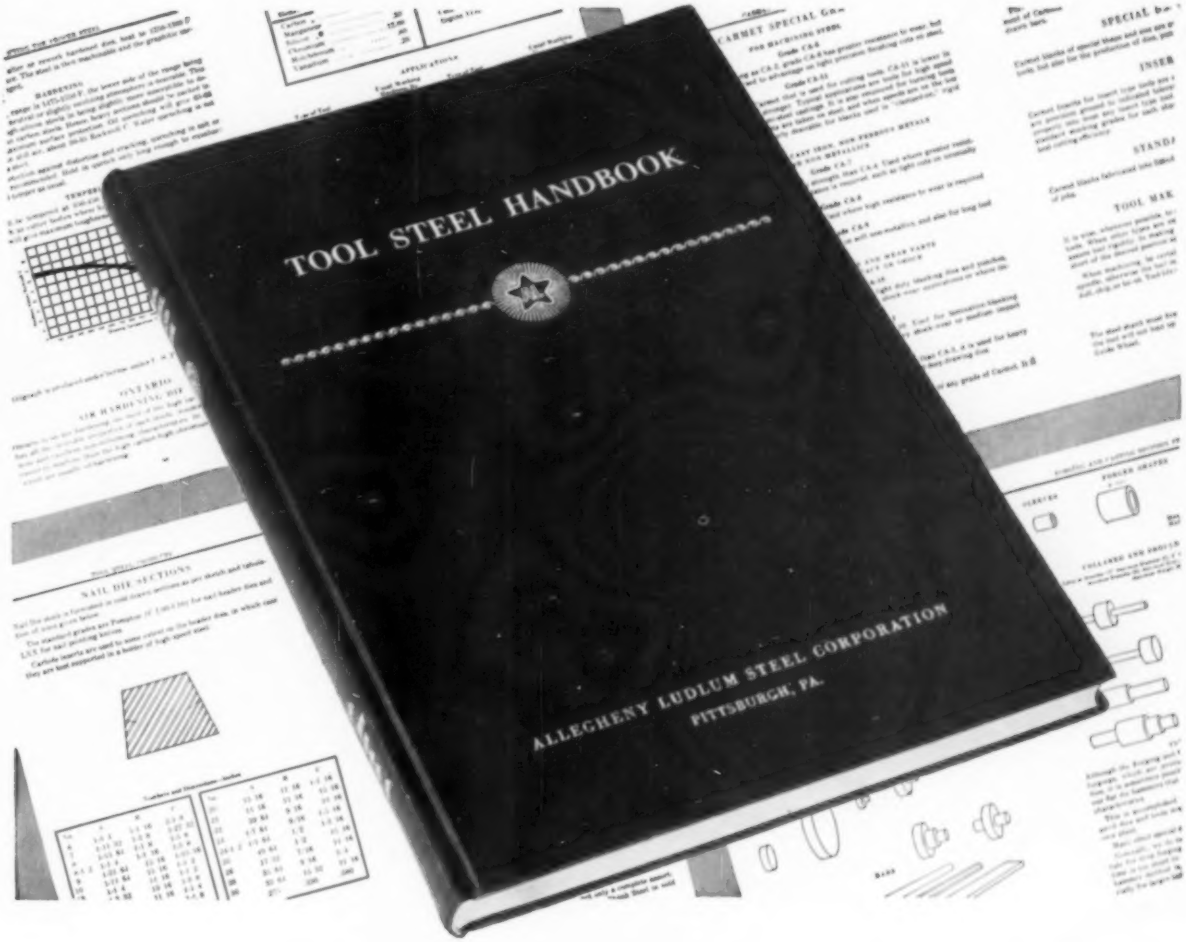
4. Application of a suitable energy threshold is capable of detonating an explosive mixture of an actively reducing metal in the presence of a strong oxidizing medium.

These conclusions have been derived from limited preliminary tests at the Aerojet-General Corp. Because this work was preliminary, the conclusions serve to indicate the direction or emphasis of future investigations which would establish the final decision on the reliability of titanium in fuming nitric acid systems.

Comparison of Finishes for Aluminum

By *WALTER E. POCOCK*, Allied Research Products, Inc., Baltimore, Md.

	Electrolytic Process	Chemical Conversion Process
Properties of Coating		
Corrosion resistance	Varies with process and treatment time. A 20-min. treatment in sulphuric acid or 30 min. in chromic acid will produce a coating resistant to 240-hr. exposure to salt spray. Scratched areas are vulnerable to corrosion.	Varies with composition and treatment time. Coatings produced after 3 to 4-min. immersion will usually resist 240-hr. exposure to salt spray. Some new proprietary compositions resist salt spray attack for 500 to 1000 hr. Scratched areas are protected by surrounding film.
Color	Clear to gray. Highly decorative dye finishes can be obtained.	Clear, iridescent yellow or brown. May be dyed but such coatings are not highly decorative or light-fast.
Paint base characteristics	Good base for paint; best after chromic acid treatment, unsealed.	Good base for paint.
Mechanical properties	Hard, excellent resistance to abrasion, brittle and may flake off in bending.	Soft, poor resistance to abrasion, flexible and will not flake off in bending.
Electrical	Insulator.	Conductor.
Weldability	Cannot be welded.	Most coatings can be welded by shielded-arc; some spot welded.
Effect of temperature	Heating at temperatures above 250° F. may cause crazing, not harmful to corrosion resistance.	Heating at temperatures above 200° F. reduces corrosion resistance.
Treatment		
Solution	(a) 15 to 25% sulphuric acid. (b) 5 to 10% chromic acid.	½ to 4 oz. per gal. proprietary mixture of chromates and activators.
Time	(a) 15 to 60 min. (b) 35 to 65 min. Sealing requires 10 to 20 min.	5 sec. to 6 min.
Power	(a) 10 to 25 amp. per sq. ft., 12 to 18 v. (b) 1 to 3 amp. per sq.ft., 40 v.	None required.
Temperature	(a) 65 to 80° F. (b) 90 to 100° F. for undyed coatings; 120 to 125° F. for coatings to be dyed.	Room temperature, not critical.
Control	Specific gravity and pH.	Titration and pH measurement.
Application	Immersion in solution; rack or container must provide adequate electrical contact pressure.	Usually by immersion but may be applied by brushing, spraying or wiping.
Equipment		
Tank	Lead-lined tank for sulphuric acid; steel tank for chromic acid.	Stainless steel or plastic-lined tank.
Temperature control	Cooling coils required for sulphuric acid treatment; heating and cooling required for chromic acid.	Heater required when room temperature fluctuates excessively.
Power source	Rectifier.	Not required.
Agitator	Air or mechanical agitator.	Not required.
Exhaust	Required.	Not required.



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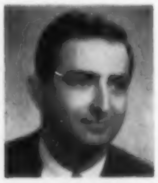

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Finishes for Aluminum Alloys

Part II — Chemical or Conversion Coatings

*By WALTER E. POCOCK**

Coatings formed by chemical reaction of aluminum with chromate solutions provide excellent resistance to corrosion and good bases for paint. They are inexpensive to produce and have replaced anodic coatings in many applications. (L 14, Al)

For many years protective coatings on aluminum alloys were obtained almost exclusively by the electrolytic or anodic treatments described in last month's *Metal Progress*. Now chemical coating has replaced anodizing for many aluminum parts when the finish does not require resistance to abrasion.

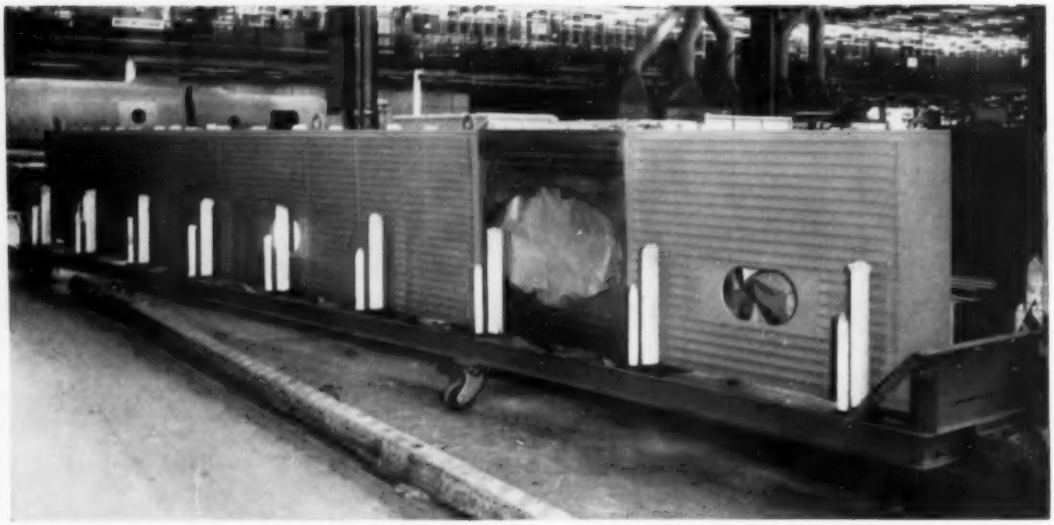
Chemical coatings are formed by reaction between a clean aluminum surface and a chemical solution applied by immersion, wiping, brushing or spraying. No electrical current is required.

Chemical treatments for aluminum have come into prominence only recently but their history goes back at least to the development of the Bauer-Vogel alkaline treatment of 1915. This process required a 2 to 4-hr. treatment. In 1930, a more practical modification known as the "Modified Bauer-Vogel" or MBV process, was patented. The procedure consists of 3 to 5-min. immersion in a solution of 2 to 5% sodium carbonate and 0.5 to 2.5% sodium chromate at 194° F. to boiling. A similar treatment is the "Alrok" process of the Aluminum Co. of America in which a solution of sodium carbonate and potassium dichromate is used with a longer treatment time and lower temperature than the MBV process. The coatings from these alkaline treatments are said to be essentially aluminum oxide, although they are thinner, softer and less protective than electrolytically formed oxides.

Acidic chromic-phosphoric treatments, generally referred to as phosphates, are of later development than the alkaline oxide processes. This type of treatment produces a thin greenish coating which has moderate protective value and is suitable as a paint base. The coating has been stated to consist mainly of amorphous chromic phosphate. While both alkaline and chromic-phosphoric processes have shown considerable merit, particularly for paint bonding, they have been far surpassed in protectiveness and ease of operation by the acidic chromate conversion treatments.

Chromate films have been applied to metals

*Development Engineer, Allied Research Products, Inc., Baltimore, Md.



The Wing Panel Is One of Many Aluminum Aircraft Components Chromated for Resistance to Corrosion. (Courtesy Lockheed Aircraft Corp.)

other than aluminum, notably zinc and cadmium, since about 1936. The first commercial treatment of this type for aluminum, the "Iridite No. 14" process, was developed by Allied Research Products, Inc. in 1950. Since then, a number of similar treatments have appeared. These are all proprietary processes, the working chemicals being packaged as powders or concentrated solutions which are added to water to make working solutions. The term "chromate conversion treatment" refers to the fact that a thin layer of surface metal is converted by chemical reaction into a nonmetallic form to produce the protective film.

Chromate Treatments

Military specification MIL-C-5541 covers chemical treatments which can be substituted for anodizing where either a corrosion resistant paint-base coating or a corrosion resistant finish which does not requre abrasion resistance is needed. Approved treatments include a number of chemically different types, among them the alkaline and chromic-phosphoric, but the most important ones are the proprietary chromates, primarily because of their outstanding corrosion resistance. In nonmilitary applications too, the chromate chemical films are widely used. For this reason, the remainder of our discussion will be limited to this group. Because of differences in proprietary processes, the discussion will necessarily be somewhat general; specific information about individual treatments should be obtained from the supplier.

The chromate bath contains a hexavalent chromium compound (chromic acid or a bichromate) and activators and has a pH in the range of about 1.0 to 2.3. The film obtained may be clear, iridescent yellow, or brown depending upon the particular treatment and operating conditions.

Chromate treatments are extremely simple to operate. The solution is made up of ½ to 4 oz. of the proprietary compound per gal., depending upon the proprietary treatment and the kind of coating desired. The clean aluminum part is immersed in the solution at room temperature for a period of 5 sec. to 6 min., rinsed in cold water sometimes followed by a hot water rinse and then it is dried. The maximum drying temperature is 200° F.; it is preferable to dry at temperatures below about 150° F.

Clear films are obtainable with dilute solutions or short treatment times, or in some instances, by using the hot rinse step as a bleach. Coloring of yellow and brown coatings with organic dyes is possible since these films are absorptive and in some instances have an affinity for certain dyestuffs. The range of colors obtainable is not as great as with dyed anodic coatings and the colors are not as attractive nor as fast to light.

While most processing is done by immersion, spray treatment is useful for handling large parts or for a high rate of production with a small

volume of solution. Brush treatment is used for touch-up or for parts too large to be accommodated in an immersion or spray process.

The chromate solution is controlled by titration and pH measurement. Proprietary compound or concentrate is added periodically to replace depletion and dragout losses. Some treatments require nitric acid additions as well, for pH regulation. Bath life depends on rate of surface treated per unit volume of solution and the amount and kind of contamination but varies also with the proprietary treatment itself. For a number of proprietary chromates currently in use, the excellent bath life obtained is an extremely important advantage.

The minimum equipment for chromating is a stainless steel tank or one with a stainless or acid resistant plastic lining, rinse tanks, and racks or baskets for supporting the work. Racks and baskets may be of aluminum, stainless steel or plastic-coated steel.

Reflector Surface of Flash Bulb Unit Is Finished With a Clear Chromate Coating. (Courtesy Heiland Research Div., Minneapolis-Honeywell Regulator Co.)

For automatic immersion treatment, chromate processes can be adapted to automatic plating equipment. In the conventional automatic spray system, the work is sprayed with the chromate solution as it is carried along on a continuous chain conveyer.

The chromate bath requires very little temperature control. Wide fluctuations in room temperature may necessitate a heating coil or immersion heater but the required heating capacity is low. Some method of stirring chemicals added to the bath must be provided but continuous agitation during processing is not necessary. Ventilation of the tank is not required since there is no gas evolution or fuming during the processing. Spray systems must be protected to prevent spraying of solution into the atmosphere.

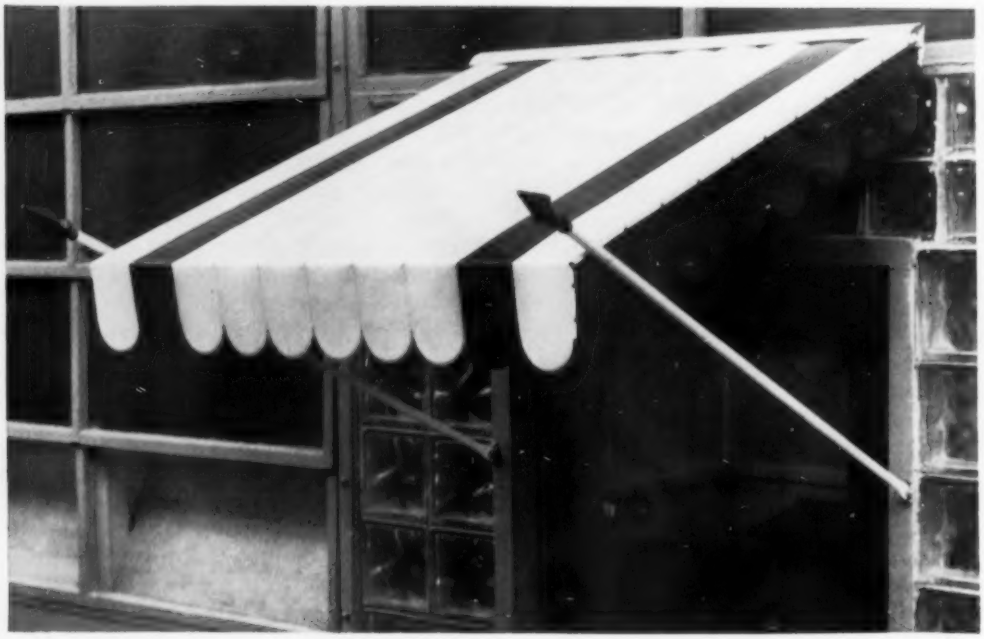
Dye solutions are kept in stainless steel, acid resistant plastic or any other material that will withstand 0.1% acetic acid at room temperature.

The chemical coating is an amorphous complex chromium chromate. It is relatively soft as formed but hardens immediately on drying and can be handled in a normal manner. Unlike anodic oxide coatings, chromate films do not increase the abrasion resistance of the aluminum surface but because of their flexibility they can be subjected to sharp bending without flaking.

Properties of Chromate Films

Color is a rough indicator of film thickness. The thinnest films are clear and as thickness increases, color becomes an increasingly deep yellow and finally, brown. Since the rate of coating formation varies with alloy composition, varying shades of yellow or brown may be obtained on different alloys processed simultaneously in the same bath. In general, chromate films are much thinner than anodic oxide coatings. Dimensional changes in processing are negligible.

Chromate coatings give much more protection against corrosion in proportion to their thickness than anodic oxides. Specification MIL-C-5541 requires that a 2024-T aluminum panel treated by the chemical process show not more than a few isolated corrosion pits after 168 hr. exposure in a 20% salt spray test or that any corrosion occurring cause not more than a 10% reduction in elongation as compared to an un-



Aluminum Awning Is Fabricated From Chromated and Painted Strip. (Courtesy Eastern Venetian Blind Co.)

exposed specimen in a standard tensile test. Yellow to brown films, if applied according to manufacturers' instructions, usually pass this test and in some instances far exceed the specification requirements. Several of the newer treatments will withstand 500 to 1000 hr. or more exposure to salt spray before any sign of corrosion. The resistance of aluminum to mild chemical attack by both alkaline and acidic solutions has also been shown to be appreciably improved by chromating.

Several factors affect corrosion resistance. In general, it is proportional to film thickness for a given treatment and alloy. As with anodic oxides, corrosion resistance is greatest for higher purity alloys and decreases with increasing amounts of alloying constituents, particularly copper and silicon. Where accelerated tests are to be made, an aging period of 12 to 24 hr. is recommended so that the film can reach complete equilibrium. Overheating, especially in drying the film, can lower the protective value as shown by salt spray. This begins to be noticeable above 150° F. and may become appreciable above 200° F. Where paint is applied over the chromate film, subsequent baking does not appear to affect the painted surface.

The protective value of the film is due in part to the presence of soluble hexavalent chromium compounds. These soluble constituents protect or heal areas where bare metal is exposed by scratching.

Chromates improve the initial adhesion of paint to aluminum, but more important is the corrosion resistance imparted to the surface under the paint. This protection greatly extends the life of the paint finish by reducing corrosion at the metal-paint interface.

Chromate films can be classed as conductors rather than dielectrics. Several proprietary treatments have been tested in the electrical industry and elsewhere in direct-current, low-frequency and radio-frequency alternating-current circuits. Surface resistance depends partly on the shape and roughness of the surface and the amount of pressure between the contacting surfaces. The increase in surface resistance due to the chromate film is usually extremely small.

Product Applications

The list of aluminum products now being chromated is a long one from which a few representative examples may be given here. Typical military items are aircraft parts, chassis for electronics assemblies, wave guides, heat exchangers, gas mask canister parts and fuse components.

Nonmilitary products include aluminum boats, truck bodies, storm doors and windows, siding, electrical junction boxes, meter bodies, pressure regulating valves, outboard motors, camera parts and fishing rod handles.

The substitution of chromates for anodized finishes in various types of applications has been impressive, especially in the aircraft industry. Parts previously anodized and now chromated include skins, structural members, hydraulic lines and castings – in fact, practically all aluminum in the aircraft that requires either a paint-base treatment or a corrosion resistant finish without the need of abrasion resistance. Some manufacturers have converted almost entirely to chromates for the obvious economy and speed-up of production obtained.

For paint-base applications, chromates have been shown to be equal or superior in performance to anodic oxides. Faster paint drying times, without harm to the paint, have been observed. One manufacturer reported superiority over anodic films in both initial bonding as indicated by impact tests and life of the paint finish in water-immersion tests. An interesting paint-base application is painted aluminum strip which is to be subsequently formed into such items as awnings, venetian blind slats and decorative molding. The strip is cleaned and chromated in a single continuous operation at line speeds of 25 to 150 ft. per min., then painted in a separate step. The painted strip can be cut and formed without flaking of the paint in the forming operation.

In the electrical field, chromates are used on chassis which require corrosion protection and low electrical resistance for ground connections. Electrical contact can be made between two chromated surfaces, or if the slight amount of resistance offered by the film is objectionable, this can be removed by sanding the contact areas. Exposed metal will be protected by the surrounding film or it can be recoated by brush after making the contact. In comparing chromated to untreated aluminum for electrical contact, the effect of corrosive environments is important. The electrical resistance of the chromated surface is somewhat higher than that of clean bare aluminum initially but the build-up of oxide on the untreated metal can completely reverse this picture in a very short time.

Machined or damaged areas on anodized surfaces can be repaired by brush chromate treatment. This method can, of course, also be used to repair extensive damaged areas of a chromated surface.

The use of aluminum with other metals in the presence of moisture can lead to galvanic corrosion. Anodic films do not protect against this type of attack to the extent that might be expected in view of their insulating nature. However, both anodic and chemical films provide some protection. Contact between aluminum and another metal, like any bimetallic contact in corrosive environments, is undesirable. Where it cannot be avoided, good practice is to cadmium plate the second metal to reduce the galvanic potential, then apply a chromate film to both the cadmium and aluminum or a chromate to the cadmium and an anodic oxide coating to the aluminum, for additional corrosion protection.

Chromate finishes on aluminum are not primarily decorative. The iridescent yellow or brown color of undyed coatings may be objectionable even though a fairly attractive golden yellow can be obtained. Dyed coatings can be quite attractive, particularly on small parts, but their use has been limited mostly to color identification. Clear films have some decorative applications. Certain mechanical and chemical finishes, such as buffed and caustic etched finishes, while improving the appearance of the aluminum surface, may increase its susceptibility to corrosion. Clear chromates provide corrosion protection in such instances without changing surface appearance. Flash-bulb reflectors are protected in this way to preserve their high luster.

In the foregoing discussion little distinction has been made between various proprietary treatments. Some of the newer treatments are decided improvements over the early ones even though basic characteristics are the same. Heavier, more protective coatings can be obtained, control of the solution is easier and bath life is longer. Furthermore, these newer treatments are more adaptable to changes in operating conditions such as temperature, concentration and treatment time.

To summarize, the chemical conversion coatings for aluminum may be used where corrosion resistance or good paint adherence is of primary importance. If abrasion resistance, electrical insulation or decorative color is required in the coating, then anodic finishing is the preferred process. A detailed comparison of the chemical and electrolytic treatments and the properties of the coatings obtained is given in the data sheet on p. 96-B.

Trained Manpower for a Technical Age

*By C. M. WHITE**

While we must build schools, educate and pay teachers, and screen college students, we can relieve the present shortage in engineering manpower by better use of technicians, upgrading the entire labor force, and giving the creative man room to grow in. (A2)

My subject is "Trained Manpower for a Technical Age". *Trained* manpower – brainpower, if you will – is the principal source of our wealth. With no more than their share of the world's materials to work with, our trained men have built the richest, the most productive country on earth, and they have accomplished this task without compulsion, moved not by fear or government edict but by the incentive of personal reward. This is the essence of the free enterprise system.

Yet now we are in trouble. We are faced with serious shortages of trained men in some categories, especially in the teaching profession and in certain of the scientific and engineering specialties. Complicating these shortages is the increasing complexity of the machines and processes that produce our goods and services. The untrained man has little place in industry today. Tomorrow he will have no place at all.

*Chairman, Republic Steel Corp. A talk given before the "Honors Luncheon", American Society for Metals, Oct. 9, 1956.

The men who fear automation claim that machines will put men out of jobs. On the contrary, it will strain our ingenuity and resources to give *enough* men *enough* training to operate and maintain tomorrow's technology.

There is already a severe shortage of teachers and teaching facilities and the need is expected to become critical as the school-age population increases – as it will rapidly during the next 10 to 15 years. It is a potential solution to the manpower problem but on the other hand this flood of students will swamp our educational system unless realistic measures are taken promptly.

In a technology such as ours, ignorance and lack of training weaken the economy. They are like diseases that can't be quarantined. But perhaps the greatest danger is this – whatever the weaknesses in our manpower training program, our rivals to the East are making education their first order of business. They are drawing the cream of their men and women into teaching by paying high salaries and offering other inducements that make teaching an elite profession in

Soviet society. They not only hire students to go to school; they offer the equivalent of bonuses to those who train for professions wherein there are manpower shortages. And, if these measures fail, they use other persuasions that only a dictatorial government can get away with.

The cold war is changing more and more into a battle for markets and economic dominance, and technical education has become a major part of Soviet strategy. The least we can do is to give to these problems of education and training the same attention we give to developing our mines, our land, our other priceless natural resources.

To begin with, let's look at the situation now confronting our schools. As the fall term gets under way, approximately one of every four Americans is in school. We have some 29,618,000 children in elementary schools, 8,111,600 in high schools and 3,232,000 in colleges and universities, a total of nearly 41 million. Furthermore, we have a shortage of about 120,000 teachers, and if you include the improperly qualified teachers the figures would be still higher.

But the main problems that are causing educators and government officials to lose sleep, are the conditions 5, 10, 15 years from now when the high birth rate of recent years swells the school population. By 1970, experts are predicting a 100% increase in college enrollments; we will have to find 16 teachers for every 10 now teaching in elementary and high schools, and 20 college teachers for every 10 now employed.

Admittedly, this is a serious situation, but I think there are two ways to look at it. From one point of view, the coming flood of students is a sobering problem. But from another, it is a profoundly exciting opportunity.

Here are thousands of potential scientists to light the way for a generation to come. Here are thousands of new engineers to translate the findings of the scientists into products and services. Here are the future doctors, lawyers, ministers, writers; here are the farmers, the steelworkers, the machinists, the electricians. Here are the men and women who will take the treasures of the earth, and the forces that bear upon the earth, and adapt them to the greater service and enrichment of mankind.

Their minds and their hands are the basic wealth of our land.

To falter before the task of developing this mine of talent to the utmost would be the rankest folly. Ten men from the class of 1970 may make discoveries worth the cost of educating their entire generation. One man from that class of 1970 may make the final discovery that will harness atomic fusion to peaceful uses. Another may be a Dr. Salk or an Albert Sauveur. But they are all worth educating.

My belief is simple: It is good business, it is good citizenship, good sense for us to work toward the goal of providing for each of our children the maximum of education and training according to his capacity.

I want to emphasize that last phrase, *according to his capacity*. I do *not* advocate a college education for everyone, or even for all with the intelligence to pass the courses. Just as there are those whose personal inclinations suit them best for a Ph.D. in physics or mathematics, there are others who will be happier and make better use of a two-year course for technicians, or a four-of five-year course in engineering.

There are still others who have no interest in formal education. You couldn't drag them to a college or a technical school with a team of mules. For them there should be on-the-job training to improve their skills and increase their earning power.

This means that our guidance program should be greatly expanded. It should begin in grade school with careful testing, observation and counseling. By the end of high school the natural capacities and aptitudes of the child should be fairly well determined, and the future outlined in general terms. This should be achieved not by persuasion or compulsion, but by stimulating the child's imagination and helping him to seek challenging and satisfying work for which he is fitted.

But we should screen as well as encourage. College entrance requirements should be made uniformly high even in those schools that have had only token requirements in the past. The goal should be to conserve college facilities for those who can make the most of them. One of our great problems today is the waste of existing facilities in many fields. Our colleges are unnecessarily crowded with students who are not suited to college training. We are rich in human resources, but not so rich that we can ignore rational concepts of conservation.

Even under the most favorable conditions, the size of the educational job confronting us is staggering. Our present school plant has been 150 years in the building. In 25 more we may have to double it. In addition to replacing teachers who retire or go into other work, we'll have to find 50,000 *new* teachers each year for at least the next decade.

The cost of the total program may force us to revise our method of school financing, but we'll have to live with it. For example, to increase our teaching force we'll have to raise the salaries to competitive levels. The incentive of higher salaries elsewhere is leading them away; we'll have to lead them back with the same incentive.

Can we do it?

The question is meaningless. We can't afford *not* to.

But we must do it without federal domination. The administration and control of our school system should continue to be in the province of the states and local communities. Also, I am against any move to have the federal government subsidize students directly as is being done in Soviet Russia. A federal giveaway would undermine the very qualities in our young people we are striving to develop. But I am in favor of privately endowed scholarships whose provisions and standards require a high degree of performance from those who receive them.

Furthermore, I believe that business and industry should cooperate with local communities in a broad program to provide part-time work and summer jobs to help students from low-income families help themselves through college or technical school.

We must consider costs as well as funds. If this is an emergency, and I believe it is, we should examine some of our educational expenditures with a very critical eye. For example, I'd like to see more money spent on equipment and teachers' salaries, and less on architecturally imposing buildings. Educators will take care of this themselves if the school boards and the donors will let them.

We should look just as critically at our teaching practices. For one thing, in many schools we're educating to a standard of mediocrity. The talented student should never be slowed down to the pace of the slower student. The slower student is not benefitted, and the talented one may be stunted. This may be one reason why many of our top students do not enter college.

Political administrations in the past have placed too much emphasis on the "common" man. We need the uncommon men, the men with unusual ability. We can find enough of them in our schools. It will cost money, but let's develop them. They'll be worth the extra cost.

In our curriculum we have neglected some key subjects. The percentage of students studying mathematics, for example, is dwindling; yet mathematics is not only a powerful tool, but a universal language. The student who does not know mathematics can never understand physics, electronics, aerodynamics. In a sense, he's like a man in a strange country with no interpreter. The man without adequate training in mathematics cannot become an engineer, a scientist, or even a very good technician. His earning power as a skilled worker may be curtailed. Yet there is a severe shortage of math teachers, and the shortage is increasing each year.

I don't know, in specific terms, how these problems can be solved. But a country that can spend $1.5 billion a year for cosmetics can build and staff a school plant to educate its young.

As for our *present* shortage in trained manpower, it is due only in part to shortcomings in our school system. For one thing, it reflects the low birth rate of the depression years. For another, it has been intensified by the war years which interrupted the training of so many of our young men. But perhaps the principal cause of the shortage is the fact that the engineers and scientists we have are so good. They have created so many new specialties, opened up so many new avenues of research, started so many new businesses and entire industries, they've created jobs faster than the schools and the on-the-job training programs could fill them!

In the long run, of course, the only solution is to train the right kinds of engineers and more of them – a solution that will emerge naturally from the increase in population and the development of our schools. If we are wise and foresighted enough, we can look forward to the day when our technology and our manpower will achieve a dynamic balance.

In the meantime, there are several things we can do to relieve the pressure, if not the problem.

To begin with, I believe that the shortage, real though it is, can be considerably relieved by using our engineers more wisely, and that the lessons we learn in this effort can be of value to us in future training programs.

The first thing I would like to suggest is a greater use of technicians. How many highly trained engineers are tied down to a clerk's or a draftsman's job? How many engineers are wasting their time doing work that could be done faster and more accurately by a technician using a computer?

The same principle applies to the upgrading of the entire labor force, particularly at the supervisory level. The greater the percentage of skilled workers in a given company, the higher the degree of skill they attain, and the broader the

base of their training, the greater will be the effectiveness of the scientific and engineering staffs in that company.

In the Republic Steel Corp., we have profited greatly from our training programs. We have an apprenticeship program, an intensive supervisory training program, and a broad-based, long-range program for building management cooperation. Another program provides special training for our key operating and maintenance employees to keep them abreast of technical developments in their field. Still another program known as the Order Maker's Institute aims at broadening the salesman's grasp of technical as well as economic problems.

Better apprentice and other on-the-job training programs, and an expansion of the two-year technical schools would go far to relieve the engineering shortage.

My second suggestion begins with a question: Why do many of our engineers and other trained specialists drift into other fields where their training may be partially wasted?

To answer this, let's consider the engineer for a moment as an individual, a human being at work in the free enterprise system. Why does he leave his chosen field? Is he underpaid? Frankly, I don't know. I suspect that some engineers are very highly paid for their ability and performance, others badly underpaid. We are going through a period in which union groups are exerting enormous pressures on our economic system, and unbalances are inevitable. However, I believe in our incentive system, and if unbalances exist they will right themselves as we become more familiar with the economic forces of this technological age.

Does he leave his profession because of unsatisfactory working conditions? This may often be the reason. The drive that makes a man into a good engineer also makes him into a complex human being. His incentive system may be highly personal. What might be a pleasant atmosphere to one man may be regimentation to another, throttling his creativity. The creative man needs growing room. He needs recognition as well as pay. He needs to know departmental as well as project goals. Cage him too tighty and his creativity dies, or he accepts that offer in California with "all expenses paid".

This may seem like sentimentality until you stop to think that it was the creative men in science, engineering, finance and management who lifted us from an agricultural economy into the most advanced technology in history.

But no reshuffling of personnel, no emergency recruitment program, no short-term measure is going to bring about any real relief of our trained manpower shortage. If our economy continues on its present course the shortages will be with us until we succeed in rebuilding our educational system to meet the needs of a scientific age.

The next 10 or 15 years probably will be the most critical. Our population will increase 20% during the next decade, while our work force will increase only 6%. Such an unbalance between consumers and producers could put a severe strain on our productive machine. Certainly it increases the need for making the most of our manpower.

This is a social problem, but not merely a social problem. It is a moral problem, but not merely a moral problem. We have a social obligation to build for the future of the race. We have a moral obligation to see that every child has an opportunity to learn, and earn a share of the good life. But as good businessmen we must also look on the rebuilding of our educational system as an economic necessity. The dividends on the stocks you own in 1970 will be determined in part by the success of our schools in the intervening years.

In a modern ore concentrator we can process a million tons of taconite rock and lose only a scattering of good ore. But in processing a million students in our present-day school system, how much do we waste of priceless brainpower and latent skills?

This is not so much a criticism of teachers and schools as of private citizens, school boards, voters on school bond issues and businessmen who have seen schools not as investments but as expenses showing no visible returns on the profit sheet. It is a criticism of a blind philosophy which uses manpower, rather than brainpower, as the measure of our human resources.

It is not too late to repair the damage. We can put up with our crowded schools and our manpower shortages a little longer while we build a school system adequate to the needs of the times. It will take the fullest cooperation between business and industry, local, state and federal governments, and the educators themselves – but it can be done! It can be done without regimentation, without loss of states' rights, without undermining the principle of free choice which permits the toymaker and the physicist, the farmer and the steelworker to make a living and enjoy the benefits of democracy.

And I believe I'll live to see the day.

New High-Strength Copper Alloy

*By J. F. KLEMENT and N. A. BIRCH**

A new British aluminum bronze containing 12% manganese has better casting properties and more attractive mechanical properties than the conventional high-strength bronzes. (Cu)

Fig. 1 – Intricate Sand Casting of New Copper-Base Alloy

ALUMINUM BRONZE CASTINGS are used where high strength, freedom from galling and resistance to fatigue and wear are required. Unfortunately, the difficulties encountered in casting the aluminum bronzes have limited their utility. Without proper foundry practice, considerable dross is formed in melting and can cause dirty castings with poor surfaces.

Recently a new high-strength copper-base alloy called Superston 40 was developed by J. Stone & Co. (Holdings) Ltd. of England, which has better castability and more attractive mechanical properties than the conventional bronzes. Thin vanes, for example, flow readily and the improved solidification and feeding characteristics insure soundness in very heavy sections. It contains about 12% manganese, melts at a low temperature, casts better, and can be readily forged, rolled and extruded. Strength, toughness and fatigue resistance are better than those of commercial aluminum bronze.

*Mr. Klement is technical director, Ampco Metal Co., Inc., Milwaukee, Wis., and Mr. Birch is division director of research, National Bearing Div., American Brake Shoe Co., St. Louis, Mo.

Superston 40 is a two-phase alloy whose nominal composition is 12% manganese, 8% aluminum, 3% iron, 2% nickel and the remainder copper. As with commercial aluminum bronzes, small amounts of lead (up to 0.4%) have been found to improve the machinability, but with corresponding loss of strength and impact values. Since the machinability of the base alloy is adequate, being generally equal to aluminum bronzes of comparable strength, the addition of lead and other minor elements is preferably held to a minimum to insure best resistance to corrosion and best welding characteristics.

The compositions of the various bronzes are shown in Table I and the average mechanical properties of static sand castings are shown in Table II. It is obvious that the new alloy has the best combination of strength, ductility and toughness. Like most materials, Superston 40 responds readily to the advantages of centrifugal casting and its mechanical properties are somewhat improved over the static cast values. The average tensile strength of centrifugal castings is 105,000 psi., yield strength, 50,000 psi. and elongation and reduction of area 30%. Centrifugal

Table I – Chemical Composition of Commercial Bronzes

Alloy	A.S.T.M. Designation	Cu	Al	Fe	Mn	Zn	Ni
Manganese bronze	B 147-52 Alloy 8A	58.0	1.25	1.25	0.25	39.25	—
Manganese bronze	B 147-52 Alloy 8C	62.0	5.5	3.0	3.5	26.0	—
Aluminum bronze	B 148-52 Alloy 9C	86.0	10.0	4.0	—	—	—
Nickel-aluminum bronze	B 148-52 Alloy 9D	79.0	11.0	5.0	—	—	5.0
Superston 40		75.0	8.0	3.0	12.0	—	2.0

Table II – Mechanical Properties of Sand-Cast Bronzes

	Tensile Strength, Psi.	Yield Strength, Psi.	Elongation %	Reduction of Area, %	Brinell Hardness	Izod Impact, Ft-Lb.	Fatigue Strength, Psi.
Alloy 8A	70,000	28,000	30	30	125	25	16,000
Alloy 8C	115,000	70,000	15	15	210	12	20,000
Alloy 9C	75,000	35,000	18	15	155	15	29,000
Alloy 9D	95,000	45,000	7	7	195	9	30,000
Superston 40	98,000	48,000	26	28	185	25	33,000

Table III – Mechanical Properties of Bronzes at Maximum Strength

	Condition	Tensile Strength, Psi.	Yield Strength, Psi.	Elongation, %	Brinell Hardness
Alloy 8C	As cast	115,000	70,000	15	210
Alloy 9D	Heat treated	115,000	70,000	5	235
Superston 40	Heat treated	125,000	75,000	12	255

Fig. 2 – Cast Valve Used in Processing Hot Sulphuric Acid

Fig. 3 – Wrought Tube Plate for Heat Exchanger

castings up to 20 in. in diameter, 12 ft. long and 3 in. thick have been produced successfully in England.

The new alloy, like other high-strength aluminum bronzes, can be heat treated to higher strengths with some sacrifice in ductility. Its mechanical properties after heat treatment are shown in Table III.

Although present uses have not been established in America, the British have developed a number of interesting applications for both the cast and wrought alloy. The intricate bilge pump casing and cover shown in Fig. 1 indicate the excellent castability obtainable. The 2-in. Y-valve shown in Fig. 2 is used to control the continual flow of 70% sulphuric acid at 120°F. Superston 40 replaced Hastelloy in this application.

The excellent fluidity of the alloy apparent during casting has also been found in welding. Welds can be made with metal-arc, tungsten-arc, carbon-arc and consumable electrodes with equal success. They are dense, fine-grained and their color matches that of the parent metal. Welds will withstand a 150° flat bend and the average mechanical properties of all-weld-metal tensile specimens are 98,000 psi. tensile strength, 50,000 psi. yield strength and 20% elongation.

The excellent hot working properties of the alloy permit the manufacture of wrought products ranging from strip as thin as 0.017 in. to heavy plate and forgings. An application of

Fig. 4 — Experimental Steel Mill Slippers Used for Evaluation of the New Alloy

the wrought alloy is the tube plate shown in Fig. 3. The English have already proven the merits of the alloy in applications requiring resistance to salt water corrosion and cavitation erosion; more than 2000 tons of high-strength marine propellers are in service. Other salt water installations include pumps, nuts and bolts, as well as pipe used for mechanical under-water supports.

In this country, steel mill slippers similar to those shown in Fig. 4 are already on trial. Although the design is not intricate, this application is one in which the high yield strength and ductility of the new alloy may prove its superiority over conventional materials. Other steel mill parts scheduled for comparative service testing include gears, connecting rods, slides, gibs and nuts.

An American company named the Superston Corp. has been formed to market the new alloy. The three concerns involved in the company are J. Stone & Co. (Holdings) Ltd. of England, Ampco Metal, Inc., of Milwaukee, Wis., and National Bearing Div. of American Brake Shoe Co., Meadville, Pa. For the time being, the alloy will be produced in the United States only by the two American companies. As the demand for the alloy increases, selected licensees may be added.

Radiations From the Atomic Industrial Forum

*By KARL F. SMITH**

Many of the uncertainties about construction materials, durability, and costs of atomic power plants will be resolved when some of the reactors now planned get into full-scale operation. (T 25)

Economics and materials problems are front and center among the people who are planning to build atomic reactors, if the discussions at the well-attended conference of the Atomic Industrial Forum held in Chicago in late September are any guide. It would also seem that cost estimates could be taken as a measure of the native optimism of the speaker! Some of the more educated guesses place the cost of power from an atomic plant at 8.6 to 11.6 mills per kw-hr., as compared with the present 6.8 mills for a well-built and well-situated plant using coal or oil. These estimates are given for reactors which can be placed in operation at the present state of the art.

Agreement is general, however, that the basis for arriving at these figures is indeed open to question. Unknown factors, to name a few, are lack of knowledge of what life to expect from fuel elements, what the cost of reprocessing the partly spent fuel will be, and what value to assign to plutonium and radioisotopes produced as by-products. In the absence of experience with full-scale *power* reactors, no one really knows the cost elements well enough to make an intellligent appraisal of either capital or operating costs.

In spite of this lack of precise figures, however, no one who has attempted to analyze things has been rash enough to predict any serious competition between atomic reactors and steam generators within the next five years. The reason for this reticence may be illustrated by a breakdown of the cost of conventionally generated power submitted by O. B. Falls, Jr., of the Atomic Power Equipment Department, General Electric Co., as follows:

*Assistant Director, Metallurgy Div., Argonne National Laboratory, Lemont, Ill.

Element of Cost	Charge (Mills per Kw-Hr.)	
Fixed charges	3.7	
Maintenance	0.5	
Fuel cost	2.6	
Total for generation at site	6.8	6.8 mills
Transmission cost		8.2
Building and incidentals		1.3
Total Cost		16.3 mills

Mr. Falls went on to say further that the cost of the power generated at site – the only factor in which atomic power might conceivably effect a saving – is only about 40% of the consumer's electric bill, the retail price. Furthermore, most or maybe all of any saving in this segment would expect to be in the fuel cost (2.6 mills), an item that amounts to only 16% of the total cost. So, even if the fuel were free, the consumer's electric bill would drop only 16%, a drop which compares favorably with the rate of reduction of conventional power costs over the past decade without benefit of any revolutionary innovation.

In the face of this dismal situation (dismal to the atomic fraternity), why do we keep on building reactors?

First: Not all power can be generated as cheaply as 6.8 mills per kw-hr. There are areas which are far removed from coal mines, oil wells and water power. The "power package" type of reactor is able to compete right now in arctic regions and other remote areas to which the transmission costs make conventional types of power plants prohibitive.

Second: The steeply increasing requirements of our modes of living may be difficult to meet by conventional power plants at some date not too far in the future. (This situation already exists in England and France.) At such time, atomic power may not find it so difficult to compete with the fossil fuels, particularly if means are actively sought to reduce the present costs of atomic power.

Third: For political reasons it would not be shrewd to neglect a technology of such potential, even if it were temporarily uneconomic. No one knows where it will lead. America could ill afford to be caught off base with a development debt that could be paid off only with time instead of dollars.

Fourth: As emphasized in the article by Frye and Gregg in September's *Metal Progress*, reactor materials and their successful development hold the key to reactor economics. Many questions can be accurately answered only by experience with an operating unit.

Major reactor types may be classified according to the method used to remove heat from the atomic chain reaction. (Nearly all proposals involve a compact and protected assemblage of fuel elements, a circulating coolant which carries the heat out to an interchanger, the latter being in effect a boiler generating steam for a turbine coupled to the electric generator.) The pressurized water types, boiling water reactors, the liquid metal cooled, gas cooled, organic cooled and homogeneous types all have certain advantages and each has its problems and liabilities. In each the designers accept one set of problems to be rid of another set. It might be suspected that it depends on a designer's background of experience whether it seems more formidable to deal with the corrosion problems of water coolants, the gamma activity of irradiated sodium, low heat transfer of gas cooled reactors, decomposition and purification problems of organic moderated types, or the maintenance difficulties with homogeneous designs. It seems that selection will be difficult until there is a major breakthrough on some materials front.

Most successful experience has been with the pressurized water reactors, one of which drives the submarine Nautilus. Many designers feel comfortable with this type, since they know at least that the beast can be made to work. But costs need to be reduced, and the need is for a long-life fuel element, one which does not have to be pulled and reprocessed every 6 to 12 months. The cost for reprocessing solid fuel materials is bound to be an expensive factor, perhaps prohibitive. There may be a sizable credit from by-product plutonium and sale of fission products, but most people are unwilling to bet their shirt on it. It may even pay to try to use fuel elements which could be discarded after their useful life. At any rate, a fuel element which would stand 60 to 70% burn-up would be very nice as an improvement over the present 1 or 2%. To develop this idea, S. B. Roboff of Sylvania Electric Co. said it would be handy to have a dozen high-flux reactors similar to the materials testing unit (MTR) in Idaho, scattered about the country.

Homogeneous reactors (those which employ liquid fuels such as uranyl sulphate aqueous slurries) are attempts to evade the reprocessing headache. Local and continuous reprocessing can be done within these types, and this in itself is a good cost reducer. *Materials* which can hold this lethal broth for any length of time, however, are hard to come by and may remain so for some time. They may never be cheap.

The organic moderated reactors are easier on their containers, but have their troubles too. They are limited to lower temperatures because hydrocarbons are poor heat conductors and decompose under heat plus intense radiation. Diphenyl and three types of terphenyls are the hydrocarbons most frequently considered for this use. Continuous refinement of the coolant is the price paid for buying one's way out of a corrosion problem.

Sodium-cooled reactors allow a low-pressure design and present comparatively minor corrosion problems to the refractory-type metals. The high coolant temperatures favor high efficiencies in the external steam cycle. At these temperatures, however, stainless steel is incompatible with uranium; a low-melting eutectic is formed. Hence, the two materials must be mechanically separated or the steel eliminated. Substitute materials are urgently needed. On the negative side of the ledger, sodium develops an isotope under irradiation which emits a troublesome gamma ray, which introduces problems in shielding or protective equipment.

The gas-cooled reactors, favored by our English cousins in their extensive program of power plants, are plagued with none of these disadvantages, but are limited in efficiency because of poor heat transfer. In view of the fact that cost of fuel is a low proportion of the cost of electricity to the consumer, it might be argued that low efficiency of utilization of heat from the chain reaction is a very minor matter, and thus the use of nitrogen as a coolant offers no disadvantages, unless someone finds that nitrogen plus irradiation above 1500° F. might nitride and embrittle all the cooling surfaces.

Unquestionably, better materials are needed to combat irradiation and corrosion. Sound and forward-looking metallurgical investigations are a prime essential. Meanwhile, "you pays your money and you takes your choice".

New Reactors

The data sheet in September *Metal Progress* lists the new reactors which are being built, and some data to indicate their nature, capacity and cost. Some of those which received attention at the Forum meeting in Chicago will now be mentioned briefly.

Charles Trilling of Atomics International Division of North American Aviation, Inc., described the organic moderated reactor experiment (OMRE), at the Idaho station. It is cooled by diphenyl and it is expected to be completed in early 1957.

The reaction which breeds uranium-233 out of thorium is of interest to W. T. Moore of the Babcock and Wilcox Co. That company plans a pressurized water reactor. It seems that 100 to 150 megawatts is close to a limiting size of reactors contained within a single pressure vessel; above that it becomes economical to hook up two smaller reactors to a single steam turbine. He thinks $250 per kw-hr. is a fair cost for initial plant investment for an atomic reactor, exclusive of the cost involved in research and development.

Another was a deuterium-moderated reactor, cooled by sodium, recently contracted for by Nuclear Development Associates for a location near Anchorage, Alaska, and still another, a conceptual design of a gas-cooled reactor by Sperry-Rand Corp. These are especially new designs.

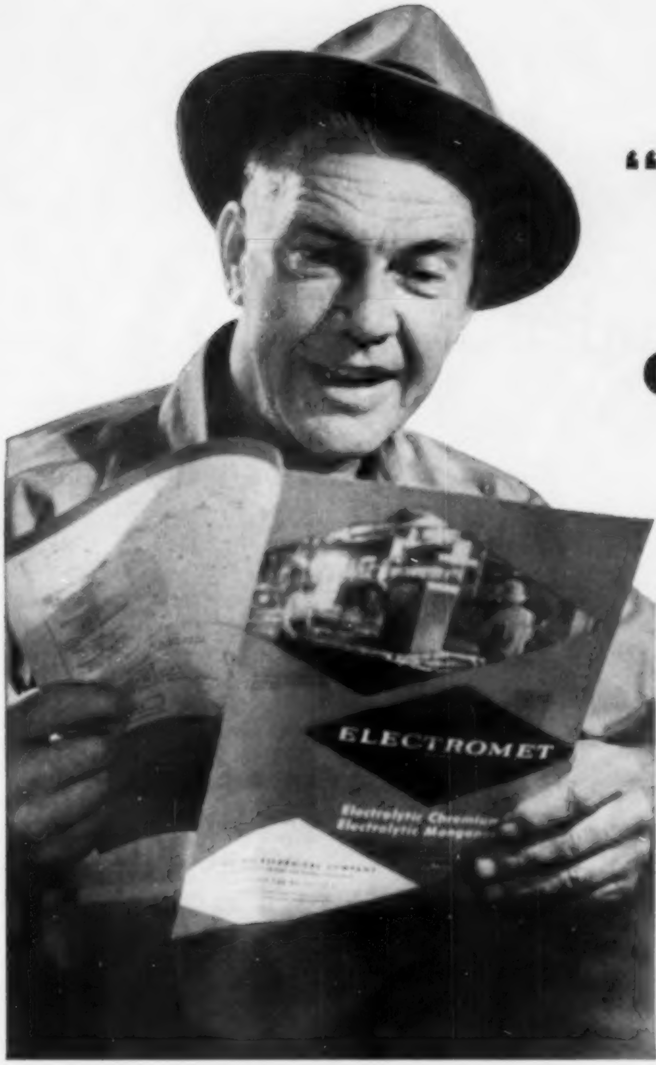
The U. S. Maritime Commission, in conjunction with the Atomic Energy Commission, is planning a nuclear-powered merchant ship. It is believed to be economical, even by present-day standards, for tankers of 65,000 tons up, in the 15,000 to 20,000-shaft-horsepower class. Pressurized water types were described by L. H. Roddis for this application, although some people would favor homogeneous type for this purpose.

Westinghouse Electric Corp., although faced with some delay in choosing a location, is proceeding with a 43-megawatt pressurized water reactor for the Belgians. This will be installed in a "plant container" made of 0.75-in. carbon steel plate as a precaution against an accidental release of radioactivity.

A homogeneous reactor, using liquid fuel (uranyl sulphate in heavy water), is being planned by Foster Wheeler Corp., for the Wolverine Electric Cooperative at Big Rapids, Mich. In spite of the neat solution of many reprocessing problems presented by this type of reactor, there are those who agree with George L. Weil's view, that homogeneous types are "a chemical engineer's dream and a plumber's nightmare". Leaks must be repaired while flooded with water, or remotely, behind a concrete wall.

A.M.F. Atomics, Inc., is planning a 22-megawatt boiling water reactor at Elk River, Minn., for completion in 1960.

So, in the next few years, some of the blanks in the cost estimates are going to be filled in. Materials development will be less dramatic and will result from painstaking effort by both public and private laboratories. We hope that it will be no less successful.



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A Simple Semi-Micro X-Ray Technique

TROY, N.Y.

While determining the orientation of small grains in a polycrystalline aggregate, a simple semi-micro X-ray technique was developed which does not require specialized equipment. It is not generally applicable to the study of areas smaller than 0.15 mm. in diameter but it can prove extremely useful in many metallurgical investigations.

The basis of the technique is a radiation shield (approximately 0.005 in. thick) fashioned from a material of high absorption coefficient, such as lead, silver, gold or platinum. The shield, pierced to admit a small portion of the X-ray beam, is placed over the specimen. The pinhole then delineates the micro-area to be irradiated in a standard X-ray camera.

In selecting the type of radiation, consideration must be given to the possibility of interference in the Laue pattern due to characteristic lines from the shield. However, if the shield is fine-grained, the interference is generally negligible. At any rate, the use of tungsten or molybdenum tube targets will eliminate characteristic lines from the shield in the back-reflection region, and a soft characteristic radiation such as that from a chromium target will free a considerable 2 θ angle from interference in transmission work.

The specimen is mounted on the stage of a table-model microscope to locate the area of interest. After the shield has been adjusted so that the pinhole is located on the pertinent area, it is fixed to the specimen with

Specimen Holder Used for Semi-Micro Inspection of Sheet Samples

Duco cement. If desired, a photomicrograph can be made of the area through the pinhole so that surface features may be referred to a fiducial mark scribed on the shield.

The specimen-shield composite mounted in a sheet specimen holder is shown in the photograph. Other specimen geometries can be handled readily in this same fashion. The assembly is mounted on a standard X-ray camera so that the specimen surface is normal to the beam.

A wire, coated with fluorescent material, serves as a beam locator. The top of the wire, ground flat at right angles to the wire axis, is positioned so that it bisects the pinhole. If the specimen holder is arranged so that half the X-ray beam strikes the locator, the pinhole is automatically centered. The locator, which is pivoted on the specimen holder, is then swung out of the way to prevent interference with the pattern.

M. J. FRASER and A. A. BURR
Department of Metallurgical Engineering
Rensselaer Polytechnic Institute

Those Controversial Abrasive Mediums

HARTFORD, CONN.

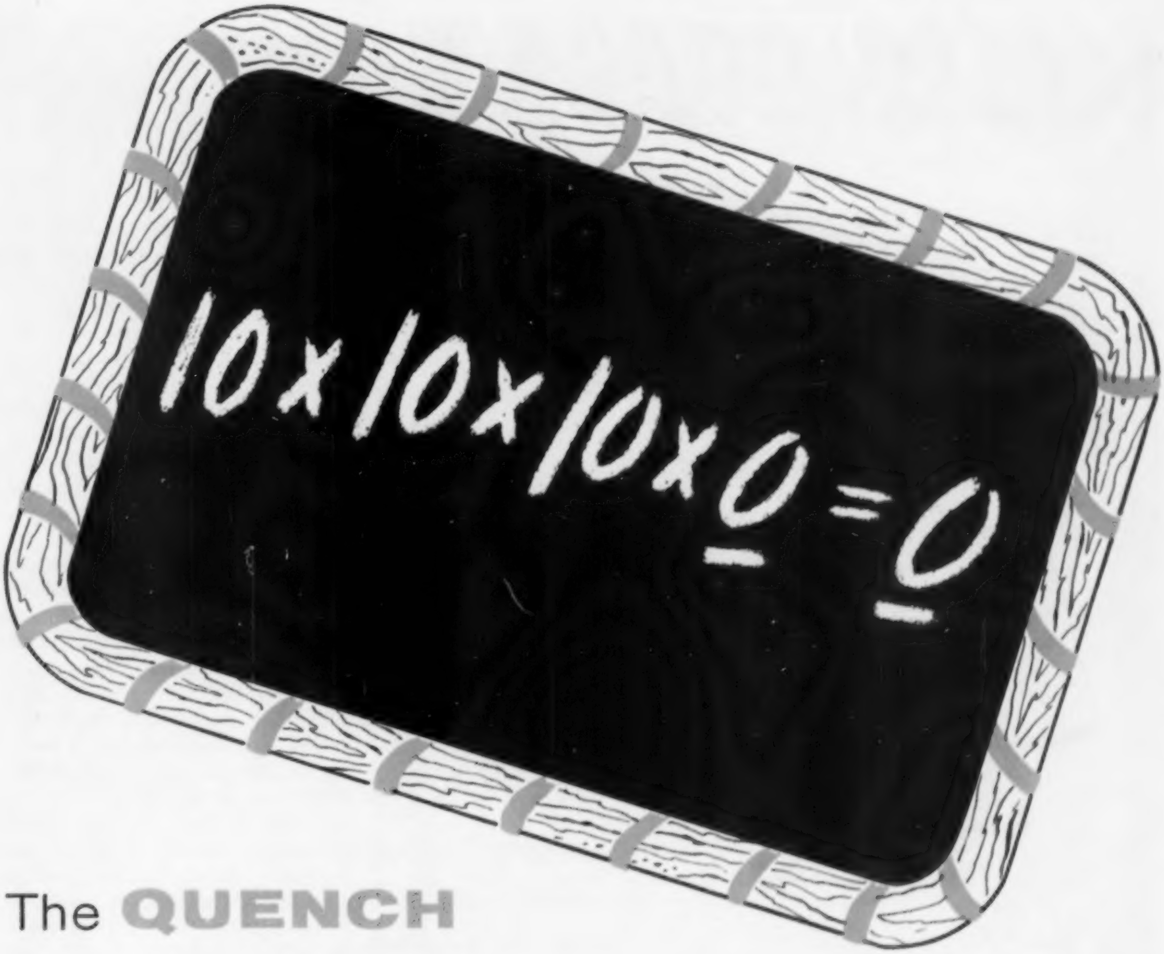
In his article "Better Barrel Finishing With Improved Abrasives" in the July issue of *Metal Progress*, Mr. Brandt of the Lord Chemical Co. implies that "coloring" and "burnishing" are synonymous. He also states that aluminum oxide chips will "produce burnishes which often cannot be matched with steel shot or steel ball operations". His implication is misleading because it puts a layman's construction on "burnishing". His statement is incorrect because it suggests that aluminum oxide chips can perform a function which can only be accomplished by hardened steel balls or shapes.

"Color" and "coloring" are terms used by metal-finishing craftsmen for numberless years to describe the effect or result of a particular operation or process. They do not describe the mechanics of the operation or process and their use is not limited to barrel finishing alone. The terms are also used in chemical cleaning, buffing, polishing and similar operations performed by hand or mechanical means.

"Color" is synonymous with luster, sheen, glow and reflectivity.

"Burnishing" to the barrel-finishing craftsman describes a distinct process or method.

All authorities are in agreement that there are two basic barrel-finishing processes. One is abrasive in its action and produces a desired finish by grinding, cutting-down, honing, lapping or polishing the surface of the parts through use of an abrasive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Abrasives . . .

—such as aluminum oxide chips—which actually removes a portion of the material being treated.

The second process is nonabrasive in action and differs from the first in that *no* metal is removed during the operation. The latter process has been recognized and described for many years as barrel *burnishing* because it is, in effect, a means of duplicating on a mass production basis the roll-down or smoothing finish obtained with the hand-craftsman's hardened steel burnishing tool. The barrel-finishing mediums universally recognized as best for this operation are hardened steel balls or shapes.

Barrel-burnishing mediums are produced in a wide variety of shapes and sizes. However, it is interesting to note that George E. Abbott, founder of the Abbott Ball Co., successfully established through exhaustive experiments that five specific shapes can be used, singly or in a mixture, to make efficient burnishing contact on parts to be finished. These shapes include balls, cones, diagonals, oval balls and pins. They are made in a variety of sizes. Other burnishing shapes are also made to meet specific requests of users. In most instances these are merely a variation or combination of the five basic shapes.

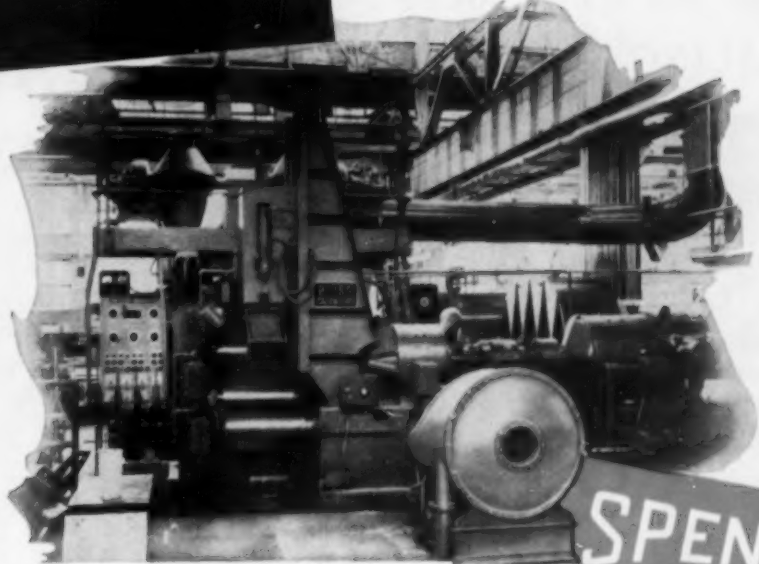
Perhaps the best way to illustrate a burnishing action is through a simple demonstration: Place a sheet of clean paper on a firm flat surface. Then, using pressure, draw the back of your thumbnail over the paper. By holding the paper at a slight angle to the light, you'll see a thin line where the pressure of your thumbnail has compressed the surface fibers.

This is burnishing in its simplest form. Further, you are able to see the results of the demonstration because your thumbnail, used as a burnishing tool, has changed the "color" or reflectivity of the paper's surface.

Diemakers, engravers, silversmiths and many other metalworking craftsmen use hand-burnishing tools of hardened and polished steel to perform a similar operation. None of these artisans would suggest that sandpaper, emery paper or even a lapping compound can be used as a substitute or that these materials will produce the same effect or "burnish" as the burnishing tool.

E. W. BLISS CO.

says:



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Abrasives . . .

The barrel-burnishing hardened steel balls or shapes are employed to duplicate the action of the hand-burnishing tool. Actually, barrel burnishing is more practical in that the mediums apply burnishing pressures uniformly to all surfaces of the parts being treated with an efficiency and economy that cannot be matched by hand-burnishing methods. The only compounds or additives required in the process are soapy water solutions or those proprietary compounds which serve as lubricants to prevent the steel mediums from scratching or skidding across parts.

Barrel burnishing is probably most useful in preparing metal surfaces for plating. The roll-down or smoothing action serves to close up minute pores in the metal, thus eliminating tiny cavities which might entrap corrosive chemicals used in the plating operations. Abrasive barrel finishing will cut or grind away the surface of the metal to a fine finish but in doing so, may also expose other subsurface cavities.

True barrel finishing also tends to work harden the surface of the metal and imparts certain properties which are not obtained through abrasive barrel finishing.

Although the art of barrel finishing has been universally practiced for many centuries, it has come into general industrial use only during the last three or four decades. Today, the craft is badly in need of a standard glossary or dictionary of terms and practices. Unfortunately, too many practitioners allow lay interpretations to slip into their daily terminology. This can only result in confusion among the many individuals who are only now discovering the benefits of this useful industrial tool. For this reason I feel it imperative that the implications and statement in Mr. Brandt's otherwise admirable article should be corrected.

JOHN F. LANGE

JACKSON, MICH.

In reading the article on barrel finishing by William E. Brandt in your July issue, we noted two contradictory statements. I feel that I should bring this to your attention since for many people such articles represent their first association with the abrasive tumbling mediums de-

Abrasives . . .

scribed and firm impressions may be formed which are not necessarily correct. This will have a very undesirable effect upon the industry.

On p. 89 of the article, Mr. Brandt discusses recent developments in the abrasive chip field and points out, "When it is properly made, the bonded chip will last longer . . ." The next sentence states, "Therefore, it takes longer time cycles to do the same work with the bonded chip." The photograph on p. 89 is captioned, "bonded triangular shapes developed for *faster cutting*". In the very next paragraph on p. 90, Mr. Brandt states that bonded triangular shapes may be used in applications "where extremely fast cutting is required". Also in the same paragraph he says, "Unfortunately, they also break down faster."

You will note at the top of p. 90 the sentence, "They tend to impinge and are not suitable for very fine finishing." In the next breath: "However, they will produce a beautiful color in burnishing operations."

I think that you can easily see that the above are two examples of contradictory statements. Regardless of the intent or the actual technical solution I feel that other readers will be as confused as I was when I read this article. I have discussed this matter with my colleagues and they were similarly confused. I have done considerable research on abrasive mediums and feel qualified to back up my statements.

D. W. MATTESON
Sales Engineer
Globe Div. of Casalbi Co.

YORK, PA.

In answering the criticisms of Mr. Lange, I should like to state emphatically that I have never at any time said or intentionally implied that "coloring" and "burnishing" are synonymous. We are quite aware of the distinction; however, we do make compounds with which you can color as well as burnish. These compounds may be used for either purpose on the particular metals for which they are compounded. Since we specialize in precision barrel finishing, we are indeed familiar with the terminology in this field. We not merely are conversant with the terminology but can readily demonstrate the dif-

Abrasives . . .

ferences between degreasing, deburring, radius formation, grinding, fine finishing, bleaching, coloring, lustering or burnishing.

We are not merely *suggesting* that fused aluminum oxide chips can be used for burnishing, but we very definitely say so. Certainly, there are a number of materials *other* than steel shapes which are also excellent burnishing mediums (see Mr. Lange's illustration of burnishing paper with the thumbnail). Steel shot or steel shapes are merely one specific type. We do not lack familiarity with steel mediums. To the contrary, we use them for certain purposes, and we also sell them!

It is not really surprising that someone should voice an exception to the article in question, since we are convinced that many responsible people in different industries do not yet realize that a properly manufactured and prepared fused aluminum oxide chip can take the place of many different mediums. As an abrasive medium, it can indeed grind away metal surfaces to a fine finish. By merely using a suitable compound, however, the chip is quickly changed into a burnishing tool. Naturally, in this condition, it will not cut. The proper compound and technique will control the chip action as desired. Therefore, this one medium (properly manufactured and prepared fused aluminum oxide chip), in connection with the specific compounds required, can be used for barrel degreasing, descaling, deburring, grinding, radius formation, fine finishing, bleaching, coloring, burnishing, peening and work hardening operations.

We have repeatedly shown manufacturers who used as many as three different mediums in successive stages in order to achieve a desired result that they can obtain an even better result by using only one medium, namely, the fused aluminum oxide chip here described, and merely changing compounds between multicycle operations. Naturally, this means fantastic economies in time, labor and materials.

In the second letter, it is clear to me that Mr. Matteson has failed to distinguish between bonded aluminum oxide chips and bonded triangular shapes. The bonded aluminum

Abrasives . . .

oxide chip looks very much like the fused aluminum oxide chip and is obtainable in certain size ranges. The statement, "When it is properly made, the bonded chip will last longer . . ." is absolutely correct and it is also absolutely correct that it takes longer time cycles to do the same work with this bonded aluminum oxide chip than it does with fused aluminum oxide chip. This is the distinction which I believe I did make and intended to make.

When Mr. Matteson speaks of bonded triangular shapes for fast cut, this is a horse of a different color. The bonded triangular shapes are also made of aluminum oxide but because of the grit size used in these shapes, the finish and color obtainable are limited. Because of their flat surfaces, bonded shapes cut much faster than the chips. Again, it is absolutely correct that these bonded triangular shapes break down very much faster than the bonded chips.

When we say that bonded aluminum oxide chips tend to impinge and are not suitable for very fine finishing, we mean precisely that. We can obtain much finer finishes with fused aluminum oxide chips. It is, nevertheless, true that one can obtain beautiful color in burnishing operations with bonded aluminum oxide chips. May I stress again the fact that a distinction must be made between these three separate items, namely (*a*) fused aluminum oxide chips, (*b*) bonded aluminum oxide chips and (*c*) bonded abrasive shapes.

William E. Brandt
Vice-President
Lord Chemical Corp.

Size Effect in Brittle Fracture

Pittsburgh

The size effect in brittle fractures is increasing in importance with the trend toward larger machines and structures. The diameters of rotor forgings for steam turbine generators are now of the order of 80 in. and large pressure vessels for nuclear reactors are being designed with wall thickness from 6 to 8 in. In both

Brittle Fracture . . .

instances, there exists a trend toward even larger dimensions.

There is some theoretical and experimental evidence indicating that the size and dimensions of the metallic piece have a pronounced influence on crack propagation, although crack initiation appears to be independent of size. The true size effect is also independent of the metallurgical differences between, for instance, a thick (8-in.) or a thin (⅛-in.) plate of the same material. In general, such metallurgical differences are additional contributory factors toward brittle fracture of large pieces.

One of the best ways to show how mere size can influence the crack propagation is to consider the bulk of the material when under stress as a reservoir of mechanical energy (strain energy). Once a crack has been initiated, the stored energy can be used to propagate the crack front. With a larger reservoir of stored energy the propagating cracks will go faster and farther. In a small piece, the driving energy may exhaust itself and consequently cause the crack to stop, whereas the energy in the larger piece can drive the crack to the point of complete separation of the structure. In the larger piece, a portion of the stored energy is converted into kinetic energy which causes sections of the broken structure to accelerate through space.

In contrast to the large amount of effort and money expended during the past decade on the problem of brittle fracture and the transition temperature phenomenon in particular, relatively little has been done about the size effect since it was first pointed out in 1924. The reason is probably the high cost of experimentation associated with this problem since the size effect can be investigated properly only with full-scale structures. However, large-scale experimentation cannot be postponed indefinitely, considering the current trend to more massive structures. With our present knowledge of crack propagation, relatively little can be learned from small laboratory specimens.

A typical question currently unanswerable is the following: Granted that the nil-ductility temperature (NDT) represents a material prop-

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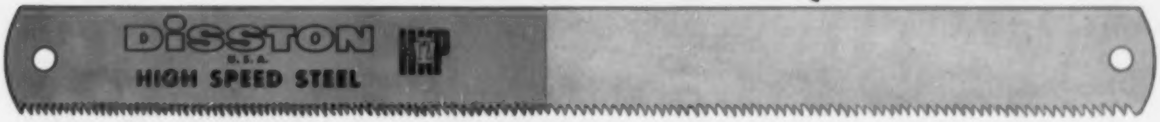
machine shop cutting

use one of these 8 sturdy



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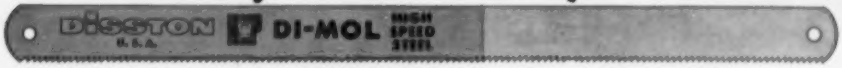

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Brittle Fracture . . .

erty related to crack initiation, at what higher temperature will the crack cease to be a freely propagating crack? The temperature difference between initiation (NDT) and freely propagating conditions (FTE) is size-dependent. It may be 70° F. for a ½-in. plate of pressure vessel steel but at present it is not known what this value may be for an 8-in. plate of the same steel. Experiments to provide this information are necessary for a safe procedure of proof testing and operation of heavy-walled pressure vessels.

F. Forscher
Atomic Power Div.
Westinghouse Electric Corp.

Skeleton in the Closet

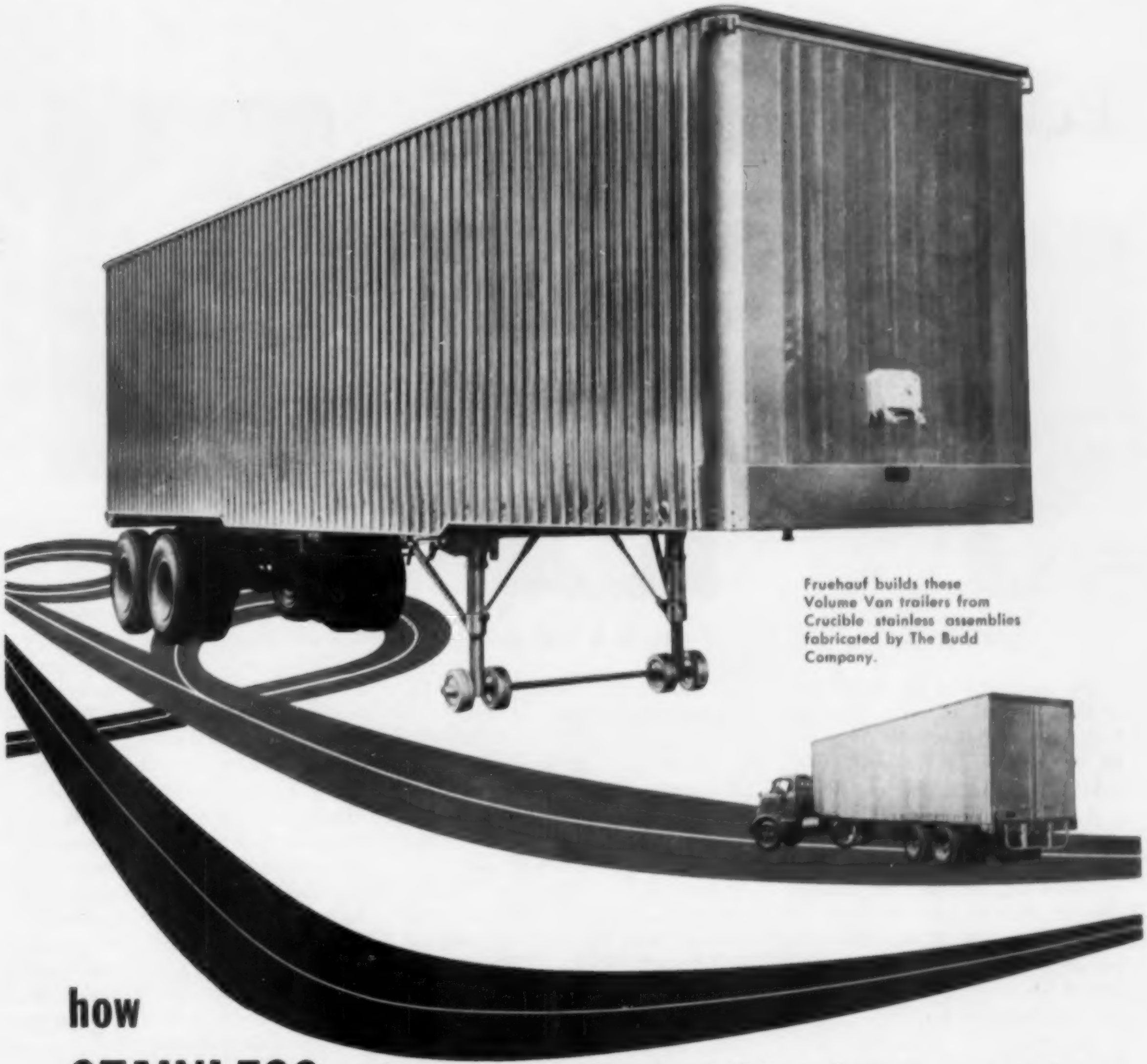
New Haven, Conn.

Those who are amused with some of the photomicrographic curiosities appearing from time to time in *Metal Progress* may like this one. You can call it the hand of a skeleton that did not quite dissolve in the melt. It really is a 1000-fold enlarge-

ment of a region activated by cold work in a single crystal of Cu_3Au from which copper has been preferentially removed during three months of soaking in an aqueous solution of $FeCl_3$ (2%).

Some significance might be attached to the fact that Professor Phillips showed this rather odd appearance to me on the very day I presented my dissertation.

Robert Bakish
Hammond Laboratory
Yale University



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And stainless lasts indefinitely. In fact, there's a tradition in the industry that "no stainless steel trailer has ever worn out." For stainless resists wear, fights corrosion, takes a lot of punishment before it will scratch or dent. Maintenance is greatly reduced.

Should your product use stainless? It may be the answer to greater efficiency, lower costs, a more attractive product for you, too. Ask your local Crucible representative, or write *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

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Crucible Steel Company of America

Canadian Distributor — Railway & Power Engineering Corp., Ltd.

Personal Mention

Robert D. Stout

The new head of the department of metallurgical engineering at Lehigh University is ROBERT D. STOUT, well-known for his work in the field of welding.

A Pennsylvania State University graduate, Dr. Stout worked four years as a metallurgist with Carpenter Steel Co., Reading, Pa., leaving there in 1939 to join the faculty of Lehigh University. He continued his advanced studies at Lehigh, and received his master's degree in 1941 and his doctorate in 1945.

Recognition of Dr. Stout's efforts in the field of welding has been widespread. In 1943 he was awarded the Lincoln Gold Medal by the American Welding Society for "conspicuous advancement of the science of welding", and in 1956 received yet another honor from this society, the meritorius service award. The $2,000 Teaching Award for "outstanding contributions to the teaching of metallurgical engineering" was presented to him in 1952. Last year he was chosen as one of the 17 official American representatives to the International Institute of Welding Conference in Switzerland.

In addition to membership in Dr. Stout is an active member of the American Welding Society, serving as chairman of the University Research Committee of the Welding Research Council and chairman of the Technical Papers Committee.

Merritt A. Williamson

MERRITT A. WILLIAMSON, manager of the research division of the Burroughs Corp., Paoli, Pa., and a special lecturer on research administration at the University of Pennsylvania, has been named dean of the college of engineering and architecture at Pennsylvania State University. Dr. Williamson's qualifications include wide experience in industry and an extensive educational background. In addition to his bachelor's, master's and doctor's degrees in metallurgy (received from Yale University), he also holds a master of science degree in aeronautics and a master's in business administration.

After graduation from Yale in 1938, Dr. Williamson became a metallurgist at Scovill Mfg. Co., Waterbury, Conn., holding this position until 1942 when he joined Remington Arms Co., Bridgeport, Conn. Following two years of wartime service with the U.S. Navy, he became director of technical research for Solar Aircraft Co., San Diego, Calif., then in 1948 moved to the research department of Pullman Standard Car Mfg. Co., Hammond, Ind., as associate director of development. He accepted his position as manager of the research division of Burroughs in 1952. Active in numerous technical organizations, Dr. Williamson is currently president of the Yale Engineering Assoc.

Richard Schoenfeld

RICHARD SCHOENFELD joined (then known as the American Society for Steel Treating) when it was only three years old and he was in Chicago studying metallurgy and metallography at Lewis Institute – now part of Illinois Institute of Technology. Shortly thereafter he found himself working with Claud Gordon, then as now marketing thermocouples and pyrometric controls. At the time Gordon was also manufacturer's representative for some eastern furnace builders. Schoenfeld did fairly well with the furnaces and by 1927 he found himself – associated with another young salesman, Cary Stevenson by name – operating in the Chicago office of a Milwaukee firm, Hevi Duty Electric Co.

Came the depression and the necessity for doing things more cheaply. Maybe some corners could be cut on furnace control equipment – perhaps by using electronics rather than mechanisms. A home-made device of this sort worked so well that the Wheeler brothers, George and Leo, took Schoenfeld and his idea into their Wheelco Instrument Co., and this simple control, based on a photo-electric cell, was first exhibited at the National Metal Exhibition in 1935. A year later an improvement was made by using an oscillator to start the controls when a moving indicator approached the set point, and this rapidly became the basis of a successful line of Wheelco instruments.

Schoenfeld became vice-president and general manager, and retained this position through two changes of

The **RIGHT** shape of

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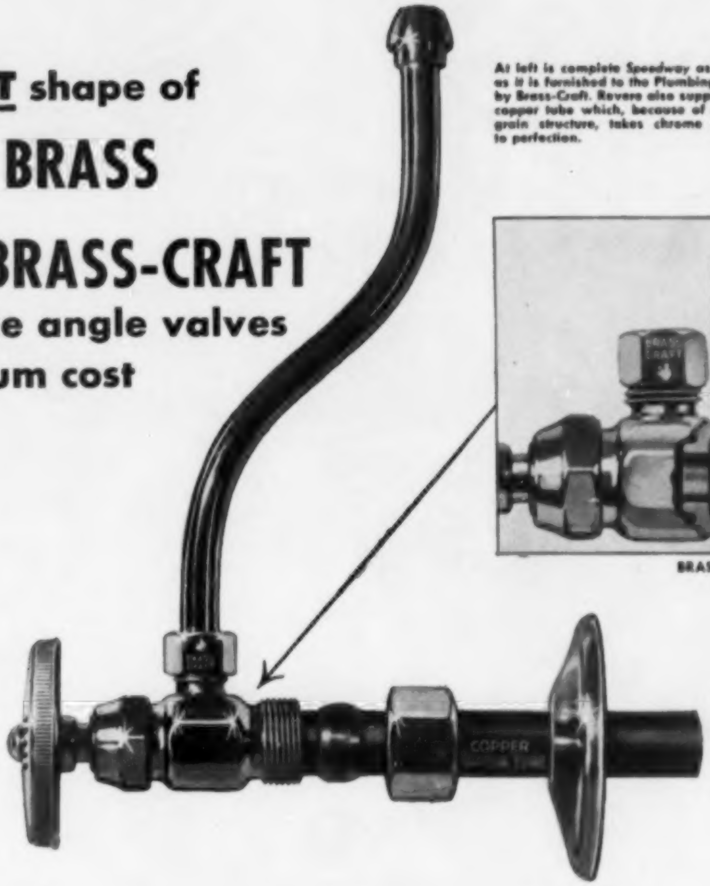
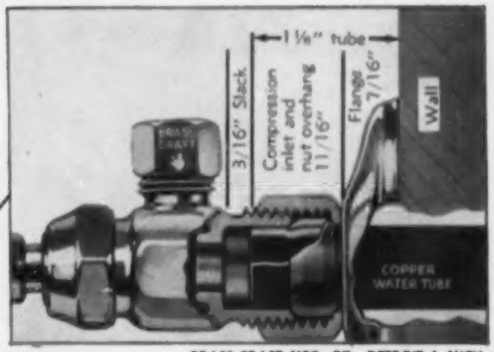
enables **BRASS-CRAFT**

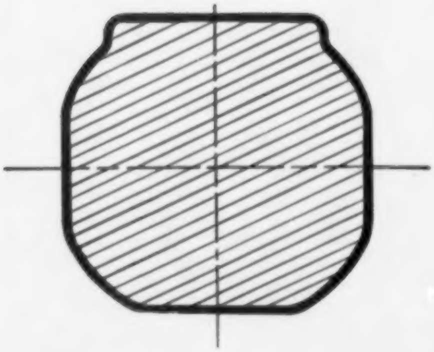
to produce angle valves at minimum cost



At left is complete Speedway assembly as it is furnished to the Plumbing Trade by Brass-Craft. Revere also supplies the copper tube which, because of its fine grain structure, takes chrome plating to perfection.



BRASS-CRAFT MFG. CO., DETROIT 1, MICH.



Cross section of Revere Brass Shape used in fabricating angle valves. Corners are rounded for easy buffing, leaving sufficient surface area for wrench pad. Top is made flat for speedy insertion of outlet.

Brass-Craft Manufacturing Company, manufacturers of Speedway Supplies, Valves & Fittings, considered two factors in selecting the Brass Shape of its angle valves.

1. Fabrication from the standpoint of production.
2. Installation and performance of the valve in use.

The shape at the left was found to be "*right*" from a production standpoint. Brass-Craft preferred it because it was nearest to the finished shape, saving metal, as well as extra cutting and machining. The fine grain structure of Revere Brass makes it especially easy to cut, drill, thread, buff and plate. Its "*right*" shape permits fabricating the valves into assemblies which save installation time. In this way, Brass-Craft is able to produce a high-quality product at minimum cost.

In addition, these brass valves resist corrosion and are compatible with copper water tube. Thus they have ready acceptance with plumbing and building contractors, as well as home owners.

Once again it is proved that there is one "*right*" product for every application. A Revere T. A. (Technical Advisor) is available to help you get the one best for you. He is always ready to cooperate in seeking ways to save money and improve your product. Call or write today.

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Personals . . .

ownership; Wheelco was bought by Lindberg Engineering Co. associates in 1944, and by Barber-Colman Co. in 1952.

Now, in 1956, Dick Schoenfeld comes back to old associates in Lindberg Engineering Co., to act as administrative assistant to Cary Stevenson, vice-president for sales and finance. At present and for some months, he will be in Cleveland, reorganizing Lindberg's sales staff so it can more efficiently handle the interests of the several divisions.

Herbert A. Ball ⊕, formerly quality control manager for the Western Brass Mills Div., Olin Mathieson Chemical Corp., East Alton, Ill., has been transferred to New Haven, Conn., to become special test superintendent of the recently created nuclear fuel division of Olin Mathieson.

Jack H. Schaum ⊕ has been named editor of "Modern Castings", the official publication of the American Foundrymen's Society. Widely known in the castings industry for his original research with both the Naval Research Laboratory and the National Bureau of Standards, Mr. Schaum spent the last 12 years in the experimental foundry department of the latter organization.

D. B. Reeder ⊕ has been appointed western manager of metallurgical services for Electro Metallurgical Co., Niagara Falls, N. Y., a division of Union Carbide and Carbon Corp. Mr. Reeder, who joined Electromet in 1929, was formerly manager of the San Francisco region for the company.

Donald L. LaVelle ⊕ recently joined Kaiser Aluminum & Chemical Sales, Inc., Oakland, Calif., as assistant pig and ingot product manager. Previously, Mr. LaVelle was manager of the aluminum department of Federated Metals Div., American Smelting & Refining Co., New York.

Eugene A. Lange ⊕, formerly research engineer with the Gray Iron Research Institute, Columbus, Ohio, is now head of the casting section, metal processing branch, metallurgy division, Naval Research Laboratory, Washington, D. C.

Personals . . .

Pat A. Santoli ●, recently discharged from the U.S. Air Force after three years active duty at Wright-Patterson Air Force Base, is now working as a research metallurgist in the elevated temperature alloy section of Allegheny Ludlum Steel Corp., Watervliet, N. Y.

Robert L. Baldwin ● has been named sales metallurgist for the Precision Steel Corp., Bridgeport, Conn. Before joining Precision Steel, Mr. Baldwin had been serving the Northeastern Steel Corp., Bridgeport, Conn., as metallurgist and chief chemist.

Louis H. Harame ●, formerly a welding engineer for Westinghouse Electric Corp., has accepted the position of nuclear engineer in the materials and fabrication section, atomic power division, Newport News Shipbuilding and Dry Dock Co., Newport News, Va.

Henry C. Kidd ● recently was transferred from New Orleans, La., to Memphis, Tenn., to serve as resident salesman for the Crucible Steel Co. of America in Arkansas, Louisiana and West Tennessee.

Fred N. Singdale ● is now serving Nevada Testing Laboratories, Ltd., Las Vegas, Nev., in the capacity of vice-president and general manager. Formerly he was associated with Baldwin-Lima-Hamilton Corp. as senior project engineer of high temperature research and later as technical representative on the West Coast.

Frank R. Baysinger ● has joined the welding section, department of metallurgical research, Kaiser Aluminum and Chemical Corp, Spokane, Wash. Before this appointment, Mr. Baysinger was senior welding engineer at Alco Products, Inc., Dunkirk, N. Y.

Carroll Edgar ●, formerly consulting mechanical engineer with the missiles systems division, Raytheon Mfg. Co., Bedford, Mass., has joined the faculty of the department of mechanical engineering at the University of Delaware in the capacity of assistant professor. He will teach courses in manufacturing methods and have charge of the machine laboratories.

Personals . . .

John L. Lamont ⊕ was recently named personnel administrator at the Metals Research Laboratories, Electro Metallurgical Co., Niagara Falls, N.Y., a division of Union Carbide and Carbon Corp. Since joining Electromet laboratories in 1929, Mr. Lamont's main work has been with engineering projects in the steel research group. Before his new appointment, he was administrative assistant to the metals group.

Elmore H. Broadhurst ⊕, former works manager of the Titusville, Pa., plant of Universal-Cyclops Steel Corp., is the new general manager of the Cyclops Div. of the company. In this capacity, Mr. Broadhurst will assume full responsibility for all operating, administrative and technical activities of the division, reporting directly to the president.

A. F. Knight ⊕ has been transferred from the Toronto works of Imperial Oxygen, Ltd., to the newly organized Winnipeg, Man., branch of the company. Mr. Knight, formerly a welding engineer, will serve as branch manager of the new office.

J. Paul Reynolds ⊕ has been appointed to the headquarters sales staff of the vacuum processing equipment division, F. J. Stokes Corp., Philadelphia, as a product specialist in charge of vacuum furnace sales and product development. Previously, he was middle Atlantic field manager for Consolidated Vacuum Corp., Rochester, N.Y.

R. P. Stemmler ⊕ has been named president of Vanadium-Pacific Steel Co., a new firm established by Vanadium-Alloys Steel Co., Latrobe, Pa. The new company will be Vanadium-Alloys main outlet for high speed and tool steels on the West Coast, and will have its main operations in the Los Angeles district. Mr. Stemmler was formerly associated with U. S. Steel Corp. and Allegheny Ludlum Steel Corp. in various capacities.

G. H. Silver ⊕ resigned as staff consultant metallurgist for Titeflex, Inc., Newark, N. J., to accept the position of metallurgist in the control engineering division, Detroit Controls Corp., Norwood, Mass.

Personals . . .

Anthony D. Zar recently was appointed sales representative in charge of the Milwaukee, Wis., district sales office of the tubular products division, Babcock & Wilcox Co. Mr. Zar held various supervisory positions with Globe Steel Tubes Co., Milwaukee, until 1955 when that firm was acquired by Babcock & Wilcox. He was then made manager of the Milwaukee general sales office.

Gordon E. Zima has joined the staff of the Bayonne, N.J., research laboratory of the International Nickel Co., Inc., as a research metallurgist. Dr. Zima was a research assistant at California Institute of Technology before coming to Inco, and received his doctorate degree from that school in April 1956. Prior to that time, he was a research engineer at the Naval Ordnance Test Station in Pasadena, Calif.

William H. Graves, formerly vice-president of engineering of Studebaker-Packard Corp., Detroit, has been named to the Board of Directors of the American Forging & Socket Co., Pontiac, Mich. After graduation from the University of Michigan in 1919, Mr. Graves joined the Packard Motor Car Co., rising to chief metallurgist and finally vice-president in charge of engineering.

Harold M. Priestley has been appointed to the metallurgical unit of the materials and processes laboratory, large steam turbine generator department, General Electric Co., Schenectady, N.Y. Mr. Priestley recently received a bachelor's degree in metallurgical engineering from the University of Pittsburgh.

Eugene M. Benson, **Joseph P. Hammond**, **Joseph J. Prislinger** and **Gerald M. Tolson** recently were appointed to the metallurgical staff of the Oak Ridge National Laboratory, Oak Ridge, Tenn. Mr. Benson and Mr. Tolson are both recent college graduates, the former from the University of Minnesota and the latter from Purdue University. Mr. Hammond formerly was an assistant professor of metallurgy at the University of Kentucky while Mr. Prislinger was a graduate student at the University of Florida.

Personals . . .

Donald H. Turner resigned his position as research engineer, Titanium Metals Corp. of America, Henderson, Nev., to accept the post of supervisor of melting and heat treating, metals research division, Armour Research Foundation, Chicago.

Kenneth L. Herrick, recently discharged from the U. S. Army, is now employed as a metallurgist at the Tilton, N.H., plant of Arwood Precision Casting Corp. A 1954 graduate of Michigan State University, Mr. Herrick served two years as an Army 1st Lieutenant at Frankford Arsenal, Philadelphia, working in the Pitman Dunn Laboratories there.

John P. Holt has been named executive assistant to the vice-president, sales, of Basic, Inc., Cleveland, Ohio. Before joining Basic in 1950, Mr. Holt was superintendent of melting at the Midvale Co., Nicetown, Pa.

Alden P. Edson has joined the staff of the New England technical field section, development and research division, International Nickel Co., Inc., New York, Formerly a metallurgist at Inco's research laboratory at Bayonne, N. J., Mr. Edson was associated with Hamilton Standard Div., United Aircraft Corp., Windsor, Conn., from 1943 until this year when he returned to Inco.

Calvin Adler, formerly plant manager of the billet casting division, Sonken-Galamba Corp., North Miami, Fla., recently joined Dixie Aluminum Casting Corp., Rome, Ga., a wholly owned subsidiary of Dixie Aluminum Corp., in the capacity of production manager.

Alfred D. Stevens has been appointed assistant general manager of Willey's Carbide Tool Co., Detroit. Prior to his recent appointment, Mr. Stevens was control manager of Kennametal, Inc., Latrobe, Pa.

Louis H. McQueen has been added to the technical services staff of Jones & Laughlin Steel Corp., Pittsburgh. Mr. McQueen has been assigned to the Detroit sales territory as a metallurgical contact engineer on sheet mill products. Prior to this new position, he had spent 20 years with the Ford Motor Co.


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Stainless Strip . . . . . Cold reduced—annealed in gauges from 0.007" to 0.125"
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Three (3) zone proportioning control
Complete control over fuel-air ratio to maintain desired atmosphere in furnace
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23

Personals . . .

Harold K. Work, director of the research division of the college of engineering, New York University, has been named professor of research management. Dr. Work will be in charge of a new evening graduate course on "Case Problems in Research Management". Another member of the faculty of the college of engineering, **Dr. Harold Margolin**, has been named associate professor of metallurgical engineering. Dr. Margolin is an engineering scientist at the University and directs an extensive research program on titanium.

John A. Parky has received a managerial post with Rolled Alloys, Inc., at the company's new South River, N. J., warehouse. Now office manager for Rolled Alloys, Mr. Parky had been purchasing agent for Rolock, Inc., Fairfield, Conn.

Maurice O. Malone, formerly with Esso Standard Oil Co., Baton Rouge, La., is now a metallurgical engineer with the Chemstrand Corp., Pensacola, Fla.

Paul Albert has been appointed supervising engineer for Westinghouse Electric Corp., Pittsburgh, and will head the materials engineering group concerned with soft magnetic alloys. Dr. Albert has been a member of this group since receiving his doctor of science degree from New York University in 1955.

Norman A. Matthews has become a member of General Electric Co.'s metallurgical products department, Detroit. His position is research engineer in connection with advance development, and his duties will involve research in the field of special inorganic materials. Mr. Matthews formerly was assistant chief metallurgist, materials research and development unit, American Brake Shoe, Mahwah, N. J.

Ray Brandenburg is now field engineer for graphitic toolsteels in the New York office of the steel and tube division, Timken Roller Bearing Co., Canton, Ohio. Mr. Brandenburg's former position was field engineer in the steel and tube division's Detroit office. This vacancy will be filled by **William J. Swan**, a member of the metallurgical staff.

Personals . . .

John P. Beal, Jr., ⊕ has been promoted to the post of production manager, Cyclops Div., Universal-Cyclops Steel Corp., Bridgeville, Pa. Associated with Universal-Cyclops since 1941, Mr. Beal's last position was assistant works manager of the company's Titusville, Pa., plant.

Herman Rischall ⊕, formerly a physical metallurgist with the Naval Research Laboratory, Washington, D.C., has joined the metals division of Utica Drop Forge & Tool Corp., Utica, N.Y., as a research metallurgist.

W. K. Eggert ⊕, a metallurgical engineer for E. I. duPont de Nemours & Co., Inc., has transferred from the Sabine River Works, Orange, Tex., to the Antioch works, Antioch, Calif.

Howard W. Schutz ⊕ is now a metallurgist at Phillips Petroleum Co., Bartlesville, Okla. Mr. Schutz was formerly connected with the laboratories of Eagle-Picher Co., Cincinnati, Ohio.

Paul Hausner ⊕ has resigned his position with Aerojet General Co., Sacramento, Calif., to accept the post of metallurgist in the materials and process laboratory of Ryan Aeronautical Co., San Diego, Calif.

Gladstone C. Hill ⊕ has been promoted to manager of sales, Indianapolis, for the U.S. Steel Corp. Associated with U.S. Steel since 1922, Mr. Hill has served the company in Pittsburgh, South Bend, Ind., Chicago and more recently as assistant manager of sales in Indianapolis.

E. H. Bucknall ⊕ has been appointed visiting professor of metallurgical engineering at the University of Texas, and will institute courses leading to the master's degree. Prof. Bucknall was formerly with the National Physical Laboratory and the Mond Nickel Co. in England, and has recently completed a three-year tour of duty as director of the National Metallurgical Laboratory in India.

J. J. Fitzgibbon ⊕ has been named foundry product manager for Whitehead Metal Products Co., Inc., New York. Another new appointment at Whitehead is **C. H. Swan** ⊕, now assistant welding product manager.

Personals . . .

George Karian, for the past two years a specialist in the sales of powder metal and industrial compacting presses for F. J. Stokes Corp., Philadelphia, has been appointed manager of the tabletting division of the company. After graduation from Pennsylvania State University in 1949, Mr. Karian joined Stokes as engineer in charge of design of compacting presses.

A. J. Babecki recently joined the metal processing branch, metallurgy division, Naval Research Laboratory, Washington, D.C. Prior to this appointment, Mr. Babecki served as research metallurgist at the general laboratories of ACF Industries, Inc., Berwick, Pa.

Thomas C. Smith has been named chief application engineer of Leeds & Northrup Co., Philadelphia. Mr. Smith has been associated with Leeds & Northrup since 1922.

Edward Dyble, formerly chief metallurgist of Cleveland Diesel Engine Div., General Motors Corp., is now associated with Bardel, Inc., Cleveland. Mr. Dyble is currently serving as chairman of the Cleveland Chapter.

F. W. Hanson has assumed new duties as Houston, Tex., district sales engineer for Electro Metallurgical Co., Niagara Falls, N.Y., a division of Union Carbide and Carbon Corp. Mr. Hanson has been a metallurgical service engineer with Electromet since 1939.

Roy C. Martin has joined the Cannon-Muskegon Corp., Muskegon, Mich., as a metallurgist. Mr. Martin was formerly affiliated with the Metals Research Laboratories, Electro Metallurgical Co., Niagara Falls, N.Y., a division of Union Carbide and Carbon Corp.

Samuel Storchheim was recently promoted to chief of manufacturing engineering and research, nuclear division, Glenn L. Martin Co., Baltimore, Md. Since joining the Martin company in 1955, Mr. Storchheim has served as head of the company's fuel element research and development program, and more recently as assistant chief of the nuclear laboratories.

Personals . . .

S. C. Massari has returned to the American Foundrymen's Society as technical director after three years in industry. Mr. Massari left the American Foundrymen's Society in 1953 to accept the position of manager of the foundry division of Hansell-Elcock Co., Chicago, and later joined the National Engineering Co., Chicago, as director of research. He originally came to the Society in 1946 as technical director.

George E. Brumbach has been named chief metallurgist of the Carpenter Steel Co., Reading, Pa. After graduation from Lehigh University in 1933, Mr. Brumbach joined the metallurgical and research department of Carpenter, rising to the position of metallurgist in 1951.

Jean Paul Elkann, vice-president of exports for Vanadium-Alloys Steel Co., Latrobe, Pa., will head a new company organized by Vanadium-Alloys and Cie des Forges de Chatillon, Paris. The new company, specializing in high speed and tool-steels, will be known as the Société Commentryenne des Aciers Fins Vanadium-Alloys. Mr. Elkann and **Roy C. McKenna**, Vanadium-Alloys' Chairman of the Board, will serve as directors of the new French company.

Clinton W. Webster is now a smelter metallurgist for Braden Copper Co., Rancagua, Chile.

George B. Howell is the new manager of sales of tubular products and cold finished steel bars at the Detroit plant of Joseph T. Ryerson & Son, Inc. Mr. Howell left the Autocar Co., Ardmore, Pa., in 1948 to join the sales staff of the Philadelphia steel service plant of the Ryerson company, and was a sales representative until his recent appointment.

G. H. Rearick, Milwaukee plant manager of Babcock & Wilcox Co.'s tubular products division, has been named to the staff of the vice-president of the company. Mr. Rearick will assist the vice-president in special work assignments. Associated with Babcock & Wilcox since 1916, he was superintendent of the division's welded tubing plant in Alliance, Ohio, before receiving his Milwaukee appointment early last year.

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Digests of Important Articles

Structural Analysis of Ball Bearing Steels

Digest of "A Discussion of the Phase Composition of Ball Bearing Steel and Its Measurement", by Donald P. Koistinen, *General Motors Engineering Journal*, Vol. 3, No. 3, p. 10-13.

THE HARDNESS and serviceability of ball bearing steel are determined by the amount of martensite, austenite and cementite in the structure after quenching. The amount of these phases can be measured by analysis of their relative areas in photomicrographs but this is a tedious process and may fail to detect some of the smaller grains.

X-ray diffraction analysis is well suited to phase composition studies and a technique for such a procedure was first outlined in 1948. Subsequent modifications make use of monochromatic X-radiation and show a degree of sensitivity such that the limit of detectability is less than 0.5% of the minor phase.

A specific application has been made to heat treating conditions on S.A.E. 52100 ball bearing steels obtained from various sources in the U.S. and from Sweden. All samples were either flats less than 3/16 in. thick or bearing balls less than ⅜ in. in diameter, inferring that they were completely hardened.

Most samples were copper-plated during heat treatment or were heat treated in an argon atmosphere furnace so that there was no reaction between the steel and the furnace atmosphere. All samples were held at the austenitizing temperature long enough to establish equilibrium conditions, then quenched and tempered at 250 to 350° F. for 30 min.

According to results of X-ray diffraction analysis, the amount of retained austenite increases continuously with increasing austenitizing temperature, while the amount of cementite decreases exponentially until at about 1800° F. all of the carbon from the cementite has been dissolved. Quenching in oil rather than in a 6 to 8% NaOH solution causes slightly more austenite to be retained even though the amount of carbon in solution is the same. Most steels of this analysis are oil quenched to minimize distortion and residual stresses.

Phase compositions of several dozen oil quenched specimens were determined and all fell close to, or within, the standard deviation band. On one occasion, when the retained austenite composition of a specimen was found to be slightly higher than expected, a check on the furnace disclosed that the controller was holding the temperature 25° F. too high. This discovery suggests the possibility of using X-ray diffraction for quality control applications.

Extrapolation of X-ray diffraction data to zero austenite intersects the temperature coordinate at about 1340° F., a significant factor since this is the accepted $Ae1$ temperature for S.A.E. 52100 steel. This is the lowest temperature at which austenite is stable and appears a more logical determination than the 1400° F. obtained by lineal analysis of reflected-light micrographs.

X-ray diffraction results also have been obtained on S.A.E. 1095 steel. The amount of retained austenite in hardened steel of this analysis increases with increasing austenitizing temperature as long as the amount of cementite decreases. All of the carbon is in solution at 1700° F., however, and at higher austenitizing temperatures no further increase in retained austenite has been observed.

The saturation value of retained austenite has been found to vary from lot to lot of S.A.E. 1095 steel, from as high as 18% to as low as 12%. The assumption that such a saturation occurs in retained austenite content of S.A.E. 52100 steel has been disproved by austenitizing samples in a flame at a temperature in excess of 2000° F. and finding that they contain as much as 55% retained austenite.

The primary factor governing the amount of austenite transforming to martensite is the difference between the temperature at which the transformation starts and the temperature to which the specimen is quenched.

A. H. ALLEN

Notch Strength of Tempered Martensite and Bainite

Digest of "Effects of a Number of Heat Treating and Testing Variables on the Notch Strength of 4340 Steel", by G. Sachs, V. Weiss and E. P. Klier, American Society for Testing Materials. Preprint No. 71, 1956, 11 p.

ONE OF THE important properties used in the evaluation of high-strength steels for aircraft applications is notch sensitivity. The notch-tension test is the most widely used index of this property. Some of the factors which affect the notch strength of a steel as measured by the test include the metallurgical structure, specimen size and notch geometry, testing temperature and strain rate.

It is generally accepted that slack-quenched structures have inferior notch properties compared to tempered martensitic structures at comparable strength levels. For this reason, only deep hardening steels are normally used for high-strength applications to assure a fully martensitic structure. Recently, however, it has been shown that S.A.E. 4340

(Continued on p. 154)

MULTIMET alloy wraps are joined by welding in the fabrication of aircraft cabin heaters.


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*U.S. and foreign patents pending

Notch Strength . . .

transformed to lower bainite can have notch properties superior to those obtained in tempered martensitic structures.

In this paper, the authors determine the effect of lower bainite on the notch strength characteristics and the 500° F. embrittlement of 4340. In addition, they show the effect at various strength levels of stress concentrations and testing temperature. Martensitic and bainitic structures were studied after tempering treatments up to 1200° F.

Martensitic structures were obtained by oil quenching from 1600° F. Two treatments were used to form lower bainite. Specimens were heated to 1600° F., furnace cooled to 1325° F. and held 1 hr. One set was oil quenched and the other set was air cooled.

The results of conventional tension tests indicate the usual increase in tensile strength as the temperature is lowered for the martensitic and bainitic structures. Ductility was almost the same at −100° F. as at room temperature but a 25% difference occurred at −320° F. for all samples tempered at temperatures of 300° F. and higher.

The ratio of tensile strength at −320° F. to that at room temperature becomes smaller as the strength values increase. It decreased linearly from about 1.4 at 160,000 psi. to about 1.1 at the 320,000 psi. level. Similar relationships held for the increase in tensile strength at −100° F. over that at room temperature.

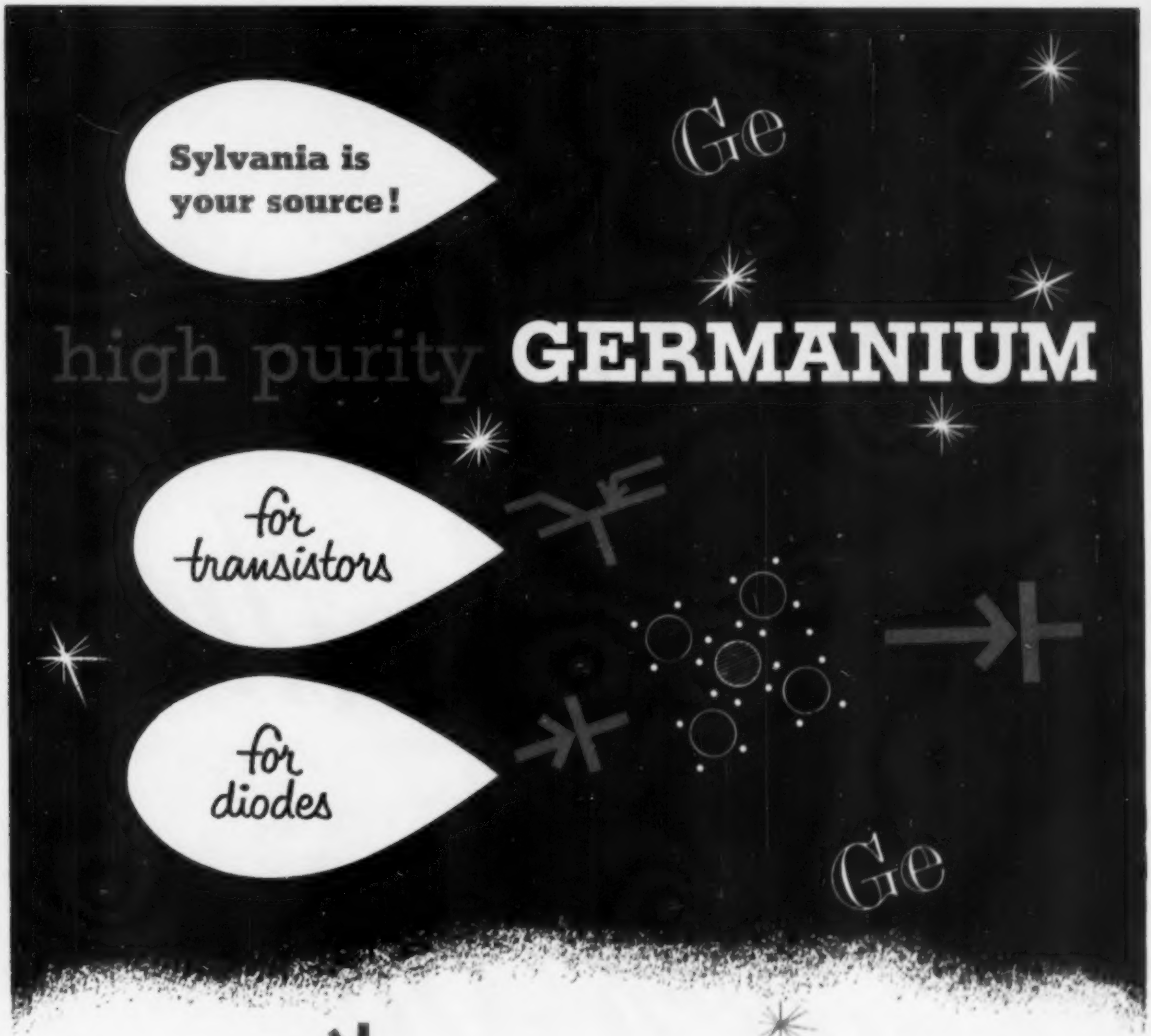
At room temperature, the magnitude of stress concentration had little effect on notch strength for samples tempered at temperatures over 800° F. Tempering at lower temperatures leads to notch values which decrease as stress concentration increases. The rate of this decrease increases as the tensile strength increases. No 500° F. embrittlement was observed in the notch tests run at room temperature. At −100 and −320° F., this embrittlement developed as stress concentration increased. At −320° F., even low stress concentration led to low values of notch strength.

At room temperature and a stress concentration of 4, the oil-cooled and the air-cooled bainitic specimens had the same notch strength as the martensitic specimen. For stress concentrations larger than 10, the air-cooled samples were slightly inferior. At −100 and −320° F., the oil-cooled bainitic structure had higher notch strengths than the standard martensitic structure.

The authors conclude that 4340 heat treated to strengths over 200,000 psi. becomes increasingly notch sensitive as the stress concentration increases. At −100 and −320° F., severe 500 to 700° F. embrittlement is experienced and its effect increases with the sharpness of the notch. At room temperature, there are only slight indications of this embrittlement. The intensity of this embrittlement at low temperature is reduced by employing a lower bainitic structure. The two-step oil quenching procedure used results in properties at high strength levels superior to those obtained from conventional martensitic structures.

C. F. Jatczak

*U.S. and foreign patents pending



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TTT-Curve for a Titanium Alloy

Digest of "Relationship Between Heat Treatment, Structure, and Mechanical Properties of a Titanium Alloy Containing 4% Cr and 2% Mo", by A. W. Goldstein and W. Rostoker, ⓐ Preprint No. 13, 1956.

THE TITANIUM ALLOY containing 4% Cr and 2% Mo is typical of the majority of titanium alloys in which the alpha phase precipitates from super-saturated beta phase during heat treatment. A TTT-curve was constructed for this alloy and microstructures, tensile and impact properties were evaluated and correlated with the temperature-time coordinates of heat treatment.

The transformation kinetics were mapped at a series of undercooling temperatures by repeated use of the following procedure: (*a*) solution treat at 1830° F. for 20 min., (*b*) quench in a constant-temperature lead bath, (*c*) hold for various times, and (*d*) water quench. Metallographic observation and electrical measurements were used to judge the amount of transformation that took place.

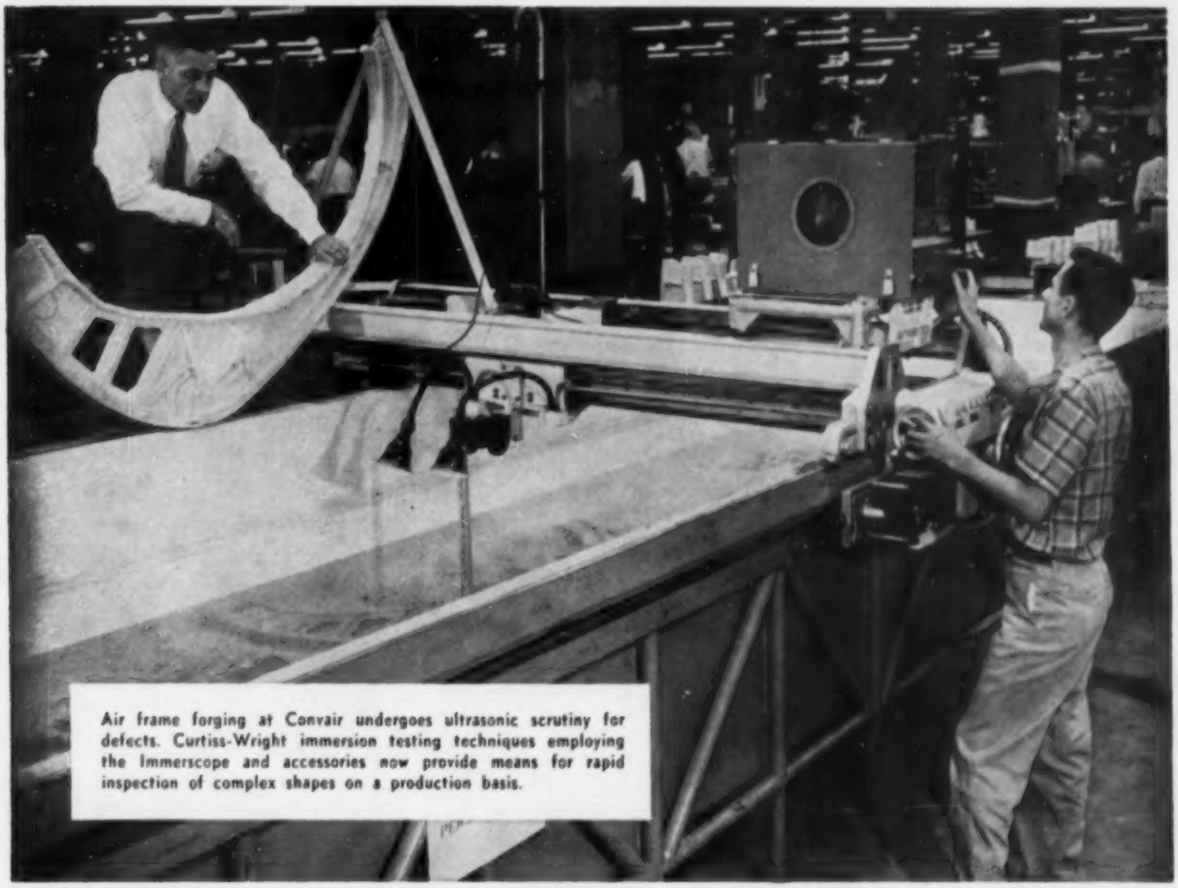
The transus temperature is between 1380 and 1470° F. Precipitation of alpha is complete in 5 min. or less except in a narrow temperature range above 1200° F. Thus, heat treatability seems primarily dependent on temperature rather than time or phase configurations.

At elevated temperatures, proeutectoid alpha is rejected in a coarse Widmanstätten pattern. The alpha platelet thickness decreased with successively lower transformation temperatures, and below 1020° F., the Widmanstätten pattern is barely discernible. The martensitic alpha-prime phase is prevalent in the early stages of transformation because of the minor enrichment of the beta phase, but in the later stages, the beta is enriched to compositions whose M_s temperatures are below room temperature and this beta is retained on quenching.

The general time-temperature effects of heat treatment were evaluated for this alloy and the data obtained indicate several conditions which develop brittleness. Transformation at 1380° F., irrespective of time, and at 1290° F., in the early stages, should be avoided. Heat treatment below 1110° causes a decrease in ductility but a considerable increase in tensile strength. Little or no increase in ductility results from prolonged annealing at 930, 1020 or 1110° F. and, in most instances, there is a significant drop in strength.

A series of isothermal heat treatments at transformation temperatures, followed by holding at 1200° F. for sufficient time to produce secondary equilibrium, were devised to render all factors invariant except the size of alpha platelets. A reduction in the dispersed phase dimensions, as established by the initial transformation temperature, can influence the strength as much as 30% at the proportion of alpha to beta developed by the 1200° F. anneal.

The beta grain sizes of specimens were adjusted by presolution treatments at various temperatures up to 2370° F. The specimens were transformed by treating at 1200° F. for 30 min. Specimens having original beta grain sizes from 0.2 to 3



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mm. in diameter were tested. Tensile and yield strengths were not affected by grain size but ductility decreased as the grain size increased.

G. A. Fritzlen

Mechanical Properties of Age Hardenable Cu-Al Alloys

Digest of "Observations on the Mechanical Properties of Two Age Hardenable Copper-Aluminum Alloys", by J. P. Dennison, *Journal* of the Institute of Metals, Vol. 84, January 1956, p. 115-117.

The addition of cobalt to precipitation hardening copper-aluminum alloys results in higher hardness after heat treating than that obtained from any other copper-base precipitation hardening alloys except the copper-beryllium alloys.

Two alloys were investigated; one contained 92.6% Cu, 6.0% Al and 1.4% Co and the other, 86.4% Cu, 6.9% Al, 1.7% Co and 5% Ni. Specimens were prepared as strip $0.10 \times 1 \times 4$ in. by hot rolling at 1650° F. and were solution treated in air at the minimum temperature at which a single-phase alloy could be obtained, and water quenched.

The Cu-Al-Co-Ni alloy reaches considerably higher strength and hardness values than the Cu-Al-Co alloy. The ultimate tensile strengths obtained were 60 and 45 tons per sq.in., respectively. The time at the precipitating temperature to reach maximum strength is longer for the Cu-Al-Co-Ni alloy – 130 and 65 hr. respectively.

Both alloys undergo similar changes when subjected to cold deformation. When the samples were cold deformed and then precipitation hardened, the samples with the greater amount of cold deformation reached their maximum strength at shorter aging times than those with less deformation. Both alloys reach their maximum strengths at approximately the same time at the precipitation temperature when they are heat treated after 50% cold deformation. An unusual feature of the results is the initial slight increase in elongation shown by material which has been cold worked before aging.

R. F. Hartmann

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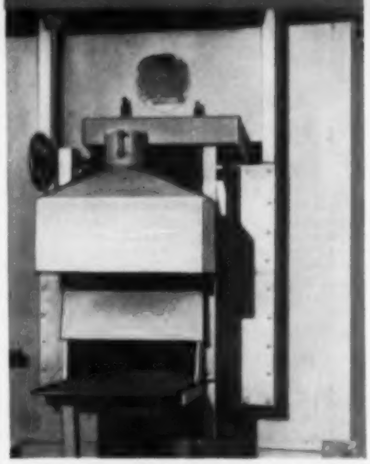

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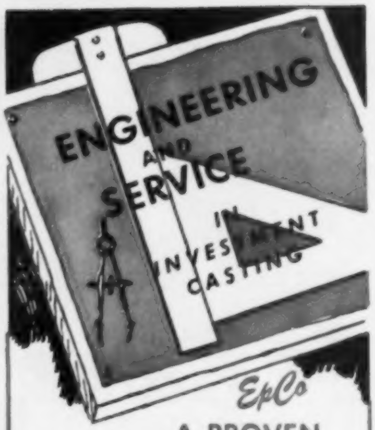

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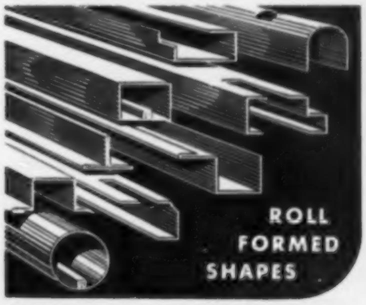

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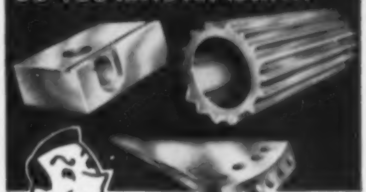

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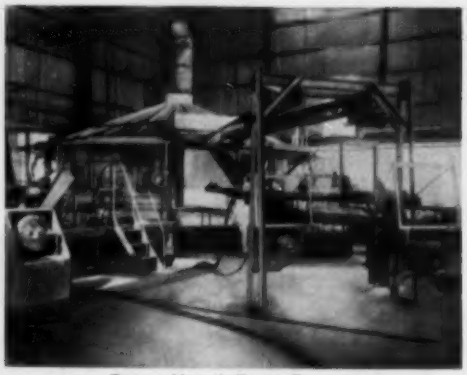

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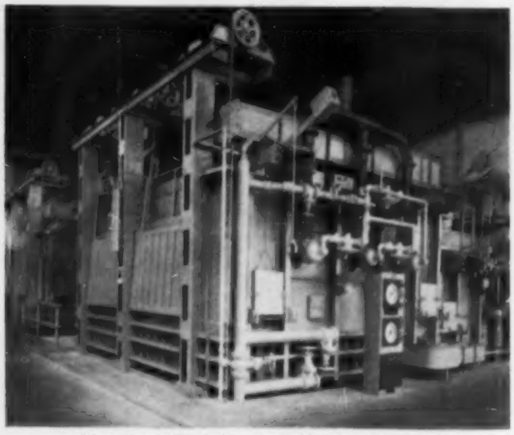

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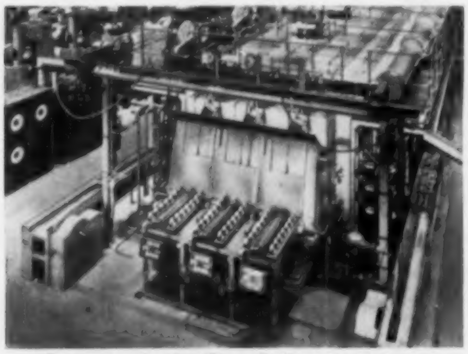

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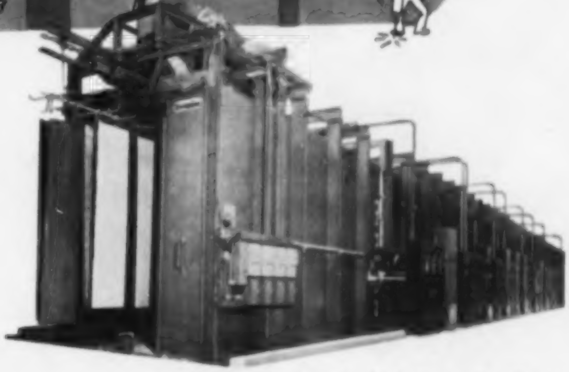

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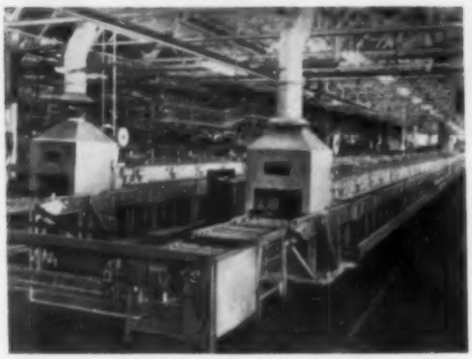

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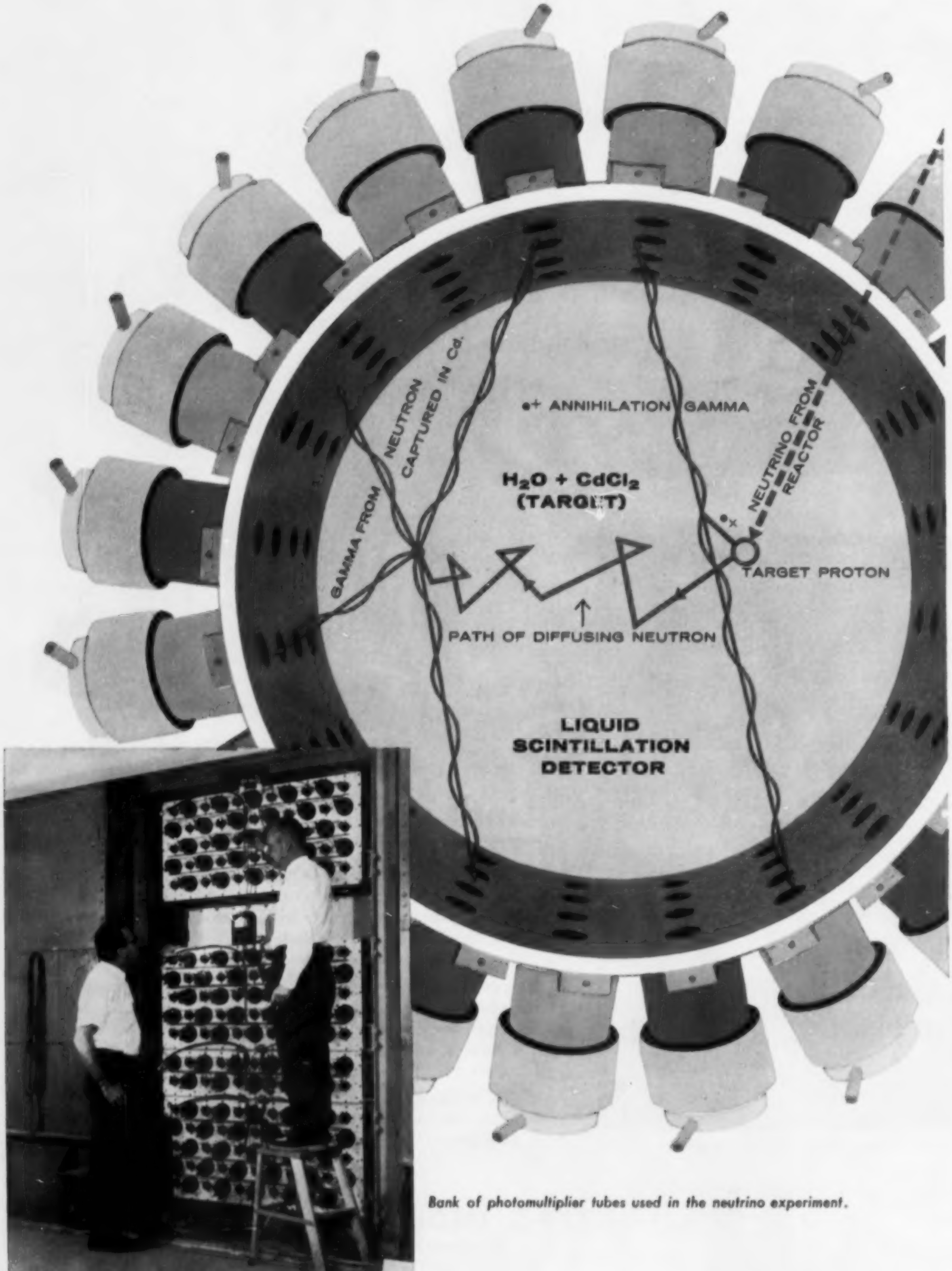

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Dephosphorization of Bessemer Steels

Digest of "The Dephosphorization of Basic Bessemer Steels", by Karl G. Speith and Hans vom Ende, *Stahl und Eisen*, Vol. 76, March 1956, p. 323-331.

THE PHOSPHORUS content of basic bessemer steel is governed by the metal temperature after the blow, the iron oxide content of the slag and the duration of the afterblow. The important thermal effect of the phosphorus slagging reaction is due to the strong temperature dependence of the phosphorus equilibrium. The duration of the afterblow cannot be extended beyond a certain limit because too much slag is produced and its iron content increases very rapidly with continued blowing. Either high slag volume or high iron content in the slag reduces the refractory life.

Since the quality required of basic bessemer steel has been continually raised during the last few years, other possible methods of dephosphorization have been sought which will produce the desired effect safely without a long blowing time. Tests were carried out in the basic bessemer plant of the Mannesman Co. in order to investigate the use of dephosphorizing agents. Basic bessemer steels of 0.06% to 0.100% phosphorus were blown as usual and after slagging off were blown again with the addition of varying amounts of dephosphorizing agents. The final phosphorus content increased with the increase in temperature and ranged from 0.020% to 0.050%. The alkali contents of the slags were not over about 4%.

The same phosphorus levels could be attained without adding any dephosphorizing agents by merely reblowing the melt for a short time with the residual slag remaining in the converter. Since a strong iron pickup results from reblowing in either instance, the final phosphorus content must be determined by the temperature and the iron content of the slag. At the same temperature, the higher the iron content of the slag the lower is the phosphorus content. Low alkali content had no additional influence on the dephosphorization.

The loss or gain in temperature during reblowing with an oxygen-enriched blast depends on the duration of the afterblow. The longer the af-

Bessemer Steels . . .

terblow, the greater is the temperature increase. This is caused primarily by the concurrent iron slagging reaction.

Dephosphorization leads to an increase in the oxygen content of the steel; however, the oxygen contents before and after dephosphorization are determined by the general relationship between the oxygen content of the basic bessemer steel and the iron content of the slag.

R. C. Shnay

Martensite Formation in Austenitic Stainless

Digest of "Formation and Tempering of Martensite in 18-8 Steels", by P. G. Bastien and J. M. B. Dedieu, *Journal* of the Iron and Steel Institute, Vol. 182, July 1956, p. 254-259.

When 18-8 Cr-Ni stainless steel is quenched from 1950° F. into various mediums at low temperatures, some of the austenite transforms to the alpha phase but appreciable amounts of martensite are formed only near absolute zero. Magnetic tests of an alloy containing 0.044% C, 18.8% Cr and 7.99% Ni showed that quenching even in liquid hydrogen gave less than 15% of alpha phase. With higher nickel contents, or after holding several days at room temperature before the low-temperature treatment, the amount of alpha phase formed decreased.

Plastic straining at room temperature produced martensite in all the steels studied. Upsetting of the steel mentioned above by 50% reduction of a 5/16-in. round specimen initiated some transformation to alpha even at temperatures as high as 240° F. When the alloy was upset at 32° F., about 90% of the austenite was transformed. Complete transformation occurred on upsetting at about −60° F. Similar steels containing 10 or 11.4% Ni required upsetting at lower temperatures for the same effect. The amounts of alpha formed by upsetting at 32° F. were about 50 and 25%, respectively.

Strain hardening, as well as the martensitic transformation, increases

Martensite . . .

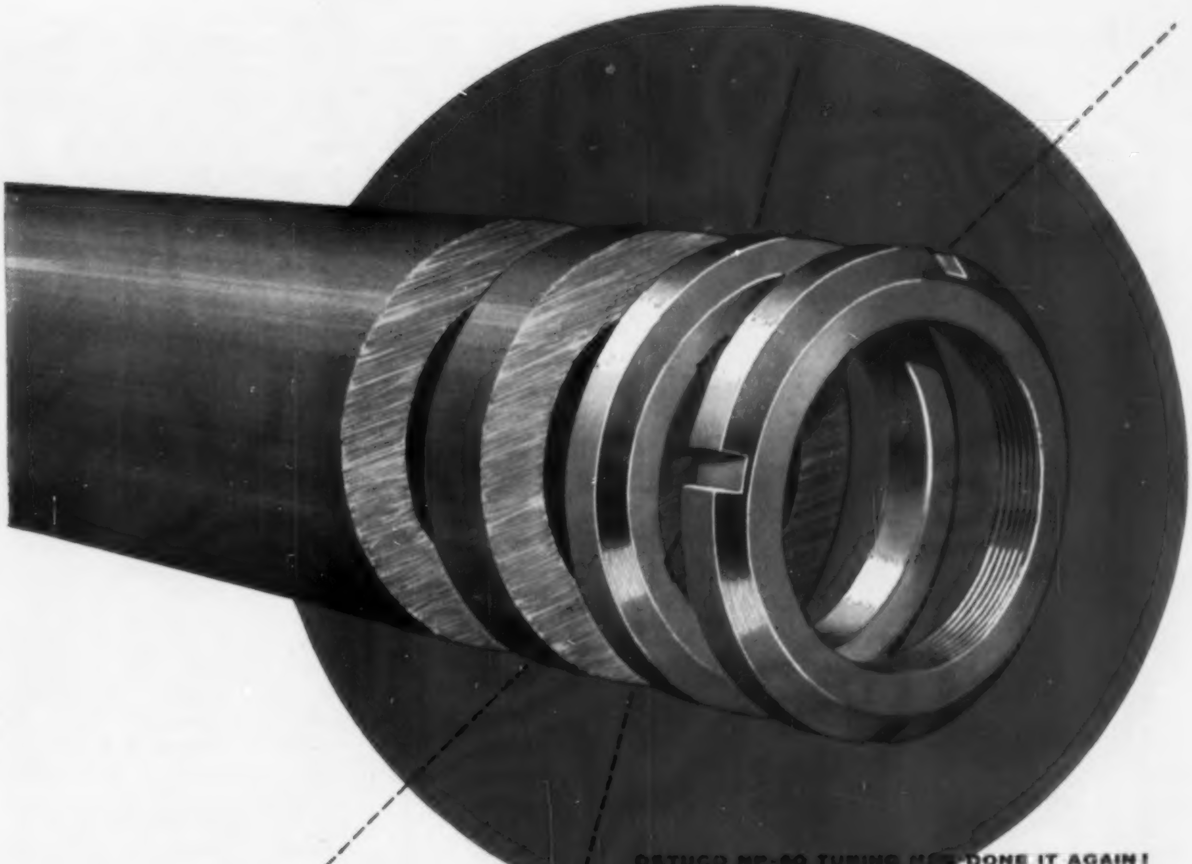
the hardness of these cold worked steels. Seventy percent reduction in area of 18% Cr steel with 9 to 10% Ni raised its hardness from about Vickers 160 to 400 or 500, while in a ferritic 18% Cr steel the same strain raised the hardness from 160 to only 200.

Holding for many days at room temperature did not stabilize the austenite against transformation by cold work as it did against transformation induced by low-temperature treatment.

The progress of tempering a wire of 17.8% Cr, 9% Ni steel transformed by cold drawing to 77% reduction of area and subsequently heated to various temperatures up to 1300° F., was studied by Chevenard's method of thermomagnetometry. Heating at temperatures below 1020° F. relieved internal stress; above that temperature, the stress-induced alpha phase reverted to gamma.

The same tempering was also studied dilatometrically by comparison with a "Pyros" standard. A cold drawn 18% Cr ferritic steel showed a slight differential contraction on tempering, while an 18.6% Cr, 11.3% Ni steel, likewise cold drawn but austenitic, showed a much greater differential expansion. Differential expansion curves of two Cr-Ni steels, transformed almost completely to alpha phase by cold drawing and then heated at increasing temperatures up to 1830° F., showed a sharp expansion anomaly at about 1075° F. and, at higher temperatures, the expected slight discontinuities corresponding to gradual transformation to gamma and carbide precipitation. The intensity of the 1075° F. anomaly was greatest in samples that had been cold drawn about 45%. Metallographic specimens quenched from about 1075° F. had structures more readily resolved than those of cold drawn specimens and with numerous small spheres resembling carbides. No satisfactory explanation of this anomaly could be found in terms of processes known to occur in steels.

By X-ray diffraction, the alpha-gamma reaction in cold drawn and reheated 18-8 steels was found to occur between 970 and 1330° F. A new phase was detected in these



Martensite . . .

steels reheated in a narrow temperature zone around 1075° F. This "C-phase" could not be identified metallographically. Neither was any metallographic etchant found to reveal the alpha phase produced by cold work. The carbide-like spheres found in cold worked 18-8 steels after reheating to 1075° F. were progressively redissolved in the gamma phase at higher temperatures.

A steel containing 17.8% Cr and 9% Ni, cold drawn 77% and almost completely transformed to alpha, maintained a hardness above Vickers 470 when tempered at temperatures up to 900° F. but softened at higher temperatures.

The hardness of steels that contained about 18.5% Cr and 10 or 11.3% Ni, transformed partially or not at all by cold work, increased from about 215 to about 290 after tempering at 900° F. but decreased at higher temperatures. This illustrates a method of hardening an 18-8 steel by a combination of a martensite transformation of part of the austenite by cold work with a structural hardening of the retained austenite by tempering.

G. F. Comstock

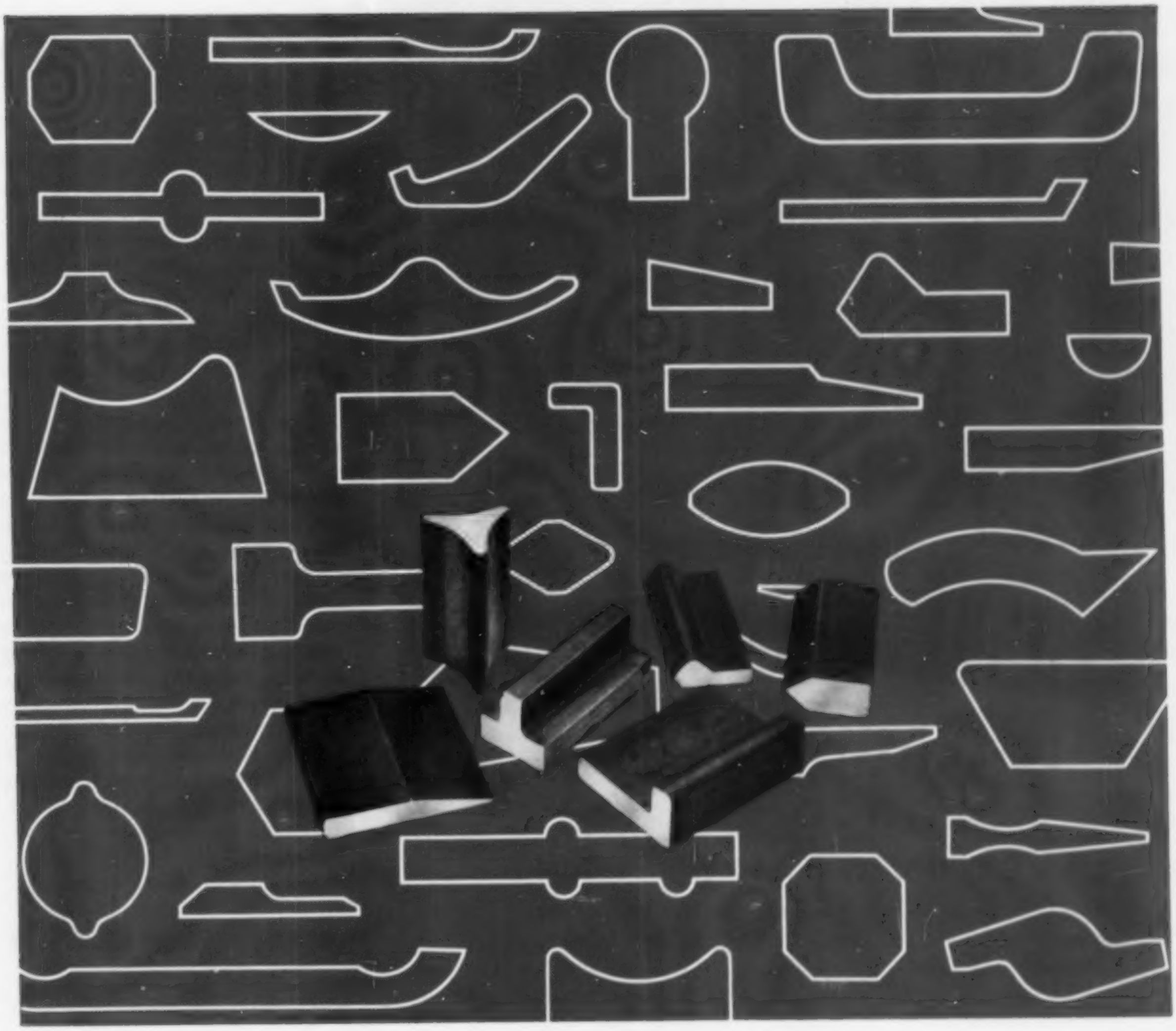
Kinetics of Pearlite Formation

Digest of "The Pearlite Reaction in Alloy Steel", by M. E. Blanter, *Metallovedenie i Obrabotka Metallov*, No. 4, 1955, p. 1-15.

The formation of pearlite from austenite depends on diffusion processes, and in unalloyed steels, the diffusion involves simply the migration of carbon atoms to form zones enriched or impoverished with respect to carbon. The problem of alloy steels is more difficult and there has not been agreement on the mechanism. This paper is a review of the present status of this problem.

Alloying elements have only a relatively small effect on the rate of diffusion of carbon in steel and theories of pearlite formation based on this idea were discarded long ago. A more logical explanation involves the diffusion of the alloying elements themselves since these diffusion rates are far slower than that of carbon. However, this theory fails to explain the fact that nickel and cobalt have opposite effects on the rate of the pearlite reaction even though their diffusion rates are similar.

The theory proposed by Blanter is based on the fact that a metastable product, rather than the stable one, is often produced initially because of more favorable kinetics. He pictures the pearlite reaction as proceeding through the following stages: (*a*) diffusion of carbon in the alloyed austenite with the formation of pearlite made up of ferrite and cementite with approximately the alloy content of the initial austenite, (*b*) a secondary process consisting in the redistribution of alloying elements by diffusion between the ferrite and cementite with the production of stable composition, and (*c*) in those alloys where a special carbide is the stable phase, the final stage of the pearlite reaction is the



Pearlite . . .

transformation of cementite to the stable carbide.

Support for this theory is found in the data of Wever and Koch and of Hultgren on the change of composition of the ferrite and carbide phases after the completion of the initial decomposition of the austenite. Microstructural studies also confirm the change from cementite to stable carbide, the third stage of Blanter's theory of the pearlite reaction in alloy steels.

Two factors, in addition to the change in the rate of diffusion of carbon, account for the variation in the effects of alloying elements on the kinetics of the pearlite reaction. One of these, the position of the A_1 temperature, has been considered by other workers. The other factor is the effect of an alloying element in reducing the loss of strain hardening in the course of the pearlite reaction. Such strain hardening could slow down the reaction by destroying coherency at the austenite-pearlite interface. Silicon is typical of the alloying elements which act in this manner.

A. G. GUY

Graphitization in White Cast Iron

Digest of "Effect of Alloying Elements on the Kinetics of Graphitization in White Cast Iron", by M. A. Krishtal, *Metallovedenie i Obrabotka Metallov*, No. 4, 1955, p. 24-27.

THERE is a divergence of opinion concerning the mechanism by which alloying elements change the rate of graphitization of white cast iron. It has been suggested by various workers that the important factors are type of crystal structure, electronic configuration or position in the periodic table. However, there are shortcomings in each of these suggestions. Recent work by Russian investigators has shown that the rate of graphitization in both alloyed and unalloyed white cast irons is limited by the mobility of iron atoms in austenite adjacent to the growing graphite particle. The present research is an additional study to determine the effect of an alloying

element on both graphitization and the diffusion of iron atoms in austenite.

Special alloys were made with Armco iron to permit control of the usual alloying elements such as silicon. The rate of graphitization during annealing was determined by microscopic analyses and it was found that the graphitizing effect decreased in the order: aluminum, silicon, nickel, cobalt, copper, vanadium and chromium. The last two elements actually decreased the rate of graphitization below that of the unalloyed white cast iron.

For comparison with these data, diffusion coefficients were obtained by decarburizing the graphitized alloys. From the fact that the Q values were lower than those for self-diffusion of iron atoms in austenite, it was concluded that the diffusion rate of vacancies was actually being measured. When the alloying elements were arranged in order of decreasing effect on rate of diffusion, it was found that the order was the same as that given above for graphitization, which indicates that the diffusion of iron atoms is the limiting factor in graphitization.

The present results were compared with other data in an effort to establish useful rules for predicting the effect that a given alloying element would have on the rate of graphitization. It was concluded that the rate of graphitization is slow when the binding energy between iron and the alloying element is large and when the difference in atomic diameter between the two is small.

A. G. Guy

Slag Control in Cupolas

Digest of "A Survey of Methods for Slag Control", by W. E. Clarke, *Journal of Research and Development*, British Cast Iron Research Association, Vol. 6, April 1956, p. 195-212.

Methods other than chemical analysis for quick estimation of the important constituents in a cupola slag offer significant possibilities as a control technique leading to better quality iron. Composition of cupola metal is closely related to, and in some ways dependent upon, slag analysis. Slag is formed from coke ash, oxidation of the metal, the re-

Slag Control . . .

fractory lining and from sand and dirt on the charge. Since these form acidic constituents (mainly SiO_2), the resulting slag would be extremely viscous if fluxes were not added to increase the basicity and fluidity.

Flux is added in the form of limestone which converts to CaO as it descends into the melting zone and then combines with SiO_2 to form a fluid slag. The SiO_2 can free itself from the coke and drip into the cupola well. However, if it is too viscous it may cause "bridging", as well as coating particles of coke which would reduce the combustion efficiency and prevent carbon pickup.

For acid-lined cupolas, the CaO content of the slag should not exceed 35% if excessive attack on the lining is to be avoided. In the basic cupola, a higher ratio of lime and magnesia to silica can be tolerated. Such a slag has considerably different properties from that in the acid cupola. For example, desulphurization can take place as well as carbon pickup. Such a basic slag can be used when the cupola is lined with either neutral or basic refractories (dolomite or magnesia). Since its refining properties are to some extent dependent upon composition, the desirability of a quick method to determine its analysis is at once apparent.

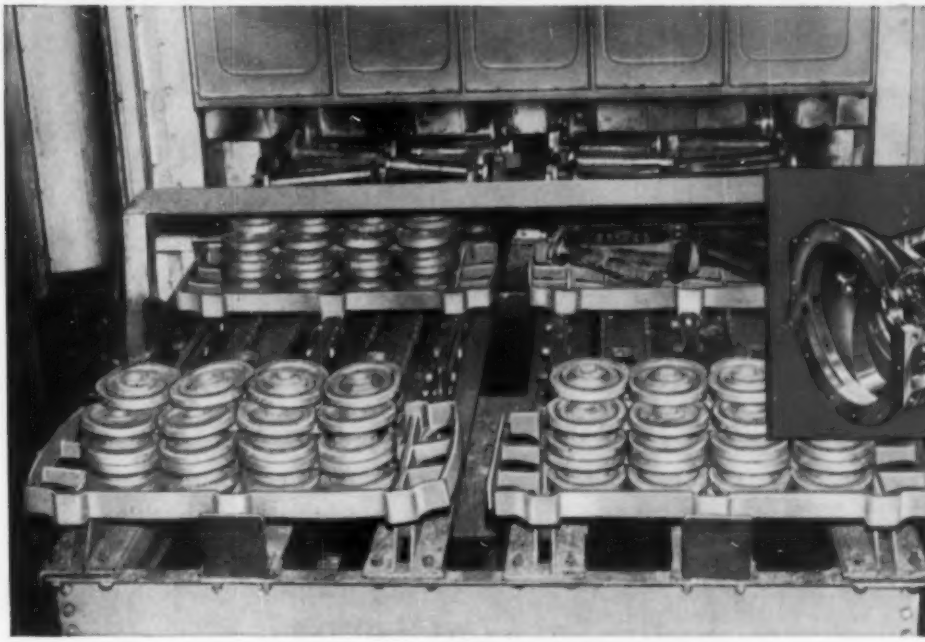
Seven methods of slag control, other than chemical analysis, are in general use. These methods make use of the physical properties of the slag. They are:

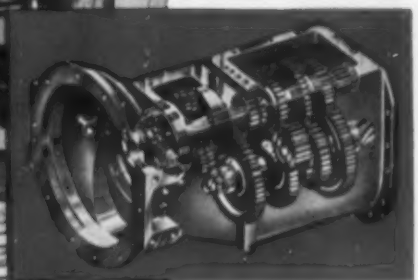
1. Visual and optical methods.
2. Viscosity and fluidity measurement.
3. Surface tension measurement.
4. Measurement of pH.
5. Measurement of electrical properties such as conductivity.
6. Measurement of the magnetic properties.
7. Use of radioactive isotopes.

Visual inspection of pancake samples, obtained by pouring a spoonful of slag into a round flat-bottomed cast iron or cast steel mold roughly 4½ in. in diameter and ⅜-in. deep, is the most common technique used for slag control in openhearth steelmaking. Its applicability to the foundry appears somewhat remote since interpretations would vary con-

(*Continued on page* 188)

"DRIVER-HARRIS TRAYS give a far lower heat-hour cost than any others we have used"... says Minneapolis-Moline





Minneapolis-Moline's new "Ampli-Torc" drive mechanism as used on their 445 tractor, which Minneapolis-Moline describes as "new from radiator to drawbar."

In heat-treating gears for the "Ampli-Torc" drive, these trays give an average life of 3000 hours of intermittent heating to 1700° F. and quenching.

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Slag Control . . .

siderably from foundry to foundry and from cupola to cupola. As the lime content of openhearth slag increases, the number of furrows or creases on the upper surface of the cooled pancake sample diminishes, and eventually, when the slag has a medium basicity, there is only a single crease. The color of the upper surface changes from matte gray-black to a more shiny black, and the lower surface gradually loses its shine until only small patches of shiny surface occur. The fracture becomes brown-black and the pores have rough instead of smooth interiors. With higher basicity, the foregoing characteristics of a "good" slag become more pronounced and a cobweb appearance of fine cracks may develop, apparently connected with the presence of P_2O_5. These slags tend to crack on cooling.

Another visual slag control technique has been applied to the production of white iron for subsequent malleableizing. Melts are made in electric furnaces. When the finishing slags are black (25 to 35% FeO), all the resulting castings require remelting or re-annealing because of mottled fractures. When the finishing slags are dark green to black (23 to 25% FeO), half the castings have to be recycled and the rest are of fair quality. When the slags are dark green, 75% of the castings are fair, 25% good; and when the slags are light green (12 to 18% FeO), all castings are good. Judgment of slag color by eye, as in this instance, is naturally subjective and has obvious limitations.

Microscopic examination of slags is possible by studying sections about 0.001 in. thick by transmitted light, also by examining powdered samples under the petrographic microscope, or by studying opaque polished samples with a metallurgical microscope. Thin sections give the most information but take a long time to prepare.

Viscosity is the most important slag property governing reactions in the cupola. A rapid determination of slag fluidity can be made in the foundry with the aid of the Herty viscometer or fluidity mold. It is a split metal mold with a conical well of 3-in. diameter and 1⅝-in. depth, having a ¼-in. tube 12 in. long attached at right angles to the bottom of the well. Slag is poured into the well and the distance it travels along the horizontal tube before solidifying is a measure of its fluidity. Results will be influenced by slag temperature, melting point, surface tension and the way in which it is poured. Sampling and pouring must be standardized to insure comparable results.

Estimation of slag basicity in openhearth and blast furnace operations has been carried out by shaking powdered slag with water and then determining the pH of the aqueous extract, or its conductance. No record of such work with cupola slags has been uncovered.

In recent years the theory of the ionic structure of slags has been proposed, and consequently considerable fundamental research into the electrical properties of both solid and molten slags has been carried out. It has been found possible to

Slag Control . . .

evaluate basicity by this method only where a binary system such as $CaO\text{-}SiO_2$ is involved. Since actual slags are mixtures of six or more components, this method does not show much promise of providing a simple procedure for slag control. The same can be said for studies of the magnetic properties of slags.

Radioactive isotopes have also been employed to trace the course of slag-metal reactions. Transfer of iron between liquid metal and iron silcate slag has been observed with the aid of Fe^{55} as a tracer. Radioactive phosphorus also has been found suitable for gaging the amount of phosphorus in the slag.

The empirical nature of the methods investigated indicates that the correlation between chemical composition of the slag and quality of the cupola metal varies with the melting process employed and the size of the unit. Consequently, the foregoing control methods would have to be considered individually for each melting unit – no small task.

Arthur H. Allen

Precipitation Hardening of Brass Powder Compacts

Digest of "Age-Hardenable Brass Alloys Through Powder Metallurgy", by E. A. Anderson and E. H. Renhack; presented at the April 1956 meeting of the Metal Powder Association.

Compacted 80-20 leaded brass powder parts have replaced those made from cold drawn screw machine rod of similar composition despite their lower strength (30,000 psi. as sintered, compared with 37,000 to 49,000 psi. for annealed rod; or 40,000 psi. when coined, compared to 52,000 to 55,000 psi. for half-hard rod). The alloy powder compacts also have much lower ductility than the wrought material. A method of improving the strength of the compacted powder by precipitation hardening has been developed by the New Jersey Zinc Co. The hardening results by precipitation of a compound of nickel and phosphorus while the compact is

Brass Compacts . . .

being cooled from the sintering temperature.

Powder produced from leaded brass containing phosphorus is not satisfactory and the phosphorus has to be added as copper phosphide. It diffuses into the brass during sintering. Sufficient precipitation of nickel phosphide for adequate hardening occurs when the compact is cooled at 95 to 230° F. per min. at the exit end of the sintering furnace. Although up to 10% nickel can be used, the recommended composition is 1.2 to 1.7% nickel with about the same amount of phosphorus and lead. Such an alloy has 43,000 to 48,000 psi. tensile strength with good ductility (30% elongation) and a hardness of Brinell 63 to 70 after compacting and sintering at 1475° F.

The disadvantages of this alloy are its grayish color, rougher surfaces of the sintered compacts, greater shrinkage in sintering and the possibility of warping and exudation of a fluid constituent at high sintering temperatures. The latter difficulty is avoided by adding iron. The alloy with the best combination of cost and properties contains 2.1 to 2.6% Ni, 0.25 to 0.5% Fe and 1.4 to 1.9% P. It can be sintered at temperatures as high as 1525° F. with only 2.3% shrinkage and no exudation. Its hardness is Brinell 70 to 80, its tensile strength 40,000 to 45,000 psi. with an elongation of 16 to 23%. The surfaces of the sintered compacts can be smoothed by coining and the coining raises the hardness to above Brinell 85 with elongation still above 10%.

From the coining experiments it appeared that precipitation hardening could be induced by strain in alloys too low in nickel and phosphorus for hardening by thermal treatment. Thus a compact of an alloy containing 0.5% Fe with only 1% Ni and 1% P, incapable of precipitation hardening when cooled from the sintering treatment at 1580° F., can be hardened to Brinell 78 and 44,000 psi. tensile strength by applying a coining pressure of 40 tons per sq.in. after sintering. This alloy has 14% elongation, and its sintering shrinkage is only 0.8%.

G. F. Comstock

Hardenability of Alloy Steels

Digest of "Some Aspects of Hardenable Alloy Steels", by H. J. French, O. O. Miller and J. W. Sands, *Journal of Metals*, Vol. 206, June 1956, p. 770-782.

In 1900, nickel was almost the only alloying element used in steel, and the amount added was usually excessive to allow for inaccuracies in heat treatment. From 1905 to 1920, the use of chromium and vanadium became popular and nickel usage decreased. Vanadium reached its peak usage as an alloy in steel about 1920 and thereafter was superseded by molybdenum. The amount of nickel and chromium used remained about constant until about 1940.

During the war years, the end-quench hardenability test was developed and the idea of the equivalence of all compositions of tempered martensite in essential properties became prevalent. With these developments came a heavy demand for alloy steels and a shortage of many alloying elements. This led to the adoption of the National Emergency steels, containing smaller amounts of nickel, chromium and

Hardenability . . .

molybdenum to replace the simpler steels of higher alloy content previously used. Although these steels served well in many instances and saved large amounts of scarce alloys, there were some instances where the concept of equal properties and service from all alloy steels of the same apparent hardenability was proved to be erroneous.

The convenient and popular Jominy end-quench test does not always indicate true hardenability, defined as the tendency of steel to transform from austenite to essentially pure martensite. The distribution of hardness across the diameters of quenched round bars of different sizes gives a better measure of hardenability, more closely correlated with commercial practice. By the latter method, a 0.40% C, 3.5% Ni steel was shown to harden more than a 0.40% C, 1% Cr steel at the centers of 1.5, 2.0 and 2.5-in. rounds, while the Jominy test showed no differences within 12/16 in. of the quenched end and greater hardness for the chromium steel at greater distances. It is important to consider the proportion of martensite attained in the structure when evaluating the hardenability of a steel or the efficiency of a quench.

The theory that all tempered martensites of the same hardness and carbon content are alike, irrespective of alloys present, was based chiefly on ductility and impact tests made only at room temperature on 0.30 to 0.50% C steels having 110,000 to 200,000 psi. tensile strength. A three-dimensional diagram, relating strength, ductility, and test severity for various conditions under which steel may be used, is presented to show that such room-temperature tests apply to only a very small part of the possible uses of heat treated steels. Also those tests lie in the region where good ductility is expected. At lower temperatures, some steels show marked embrittlement after tempering at 500 to 700° F.

Notches have widely different effects on different alloy steels. For instance, although the notched tensile strength of various 0.40% C alloy steels, heat treated to less than 180,000 psi. unnotched tensile strength, were all closely similar, manganese and chromium steels had much lower

Tool Steel Topics

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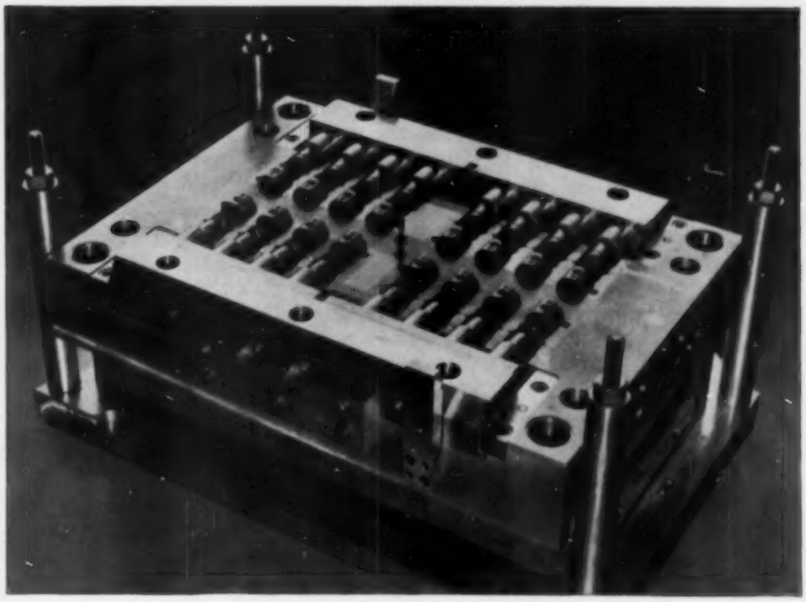

This die, made from Lustre-Die by Eagle Tool and Machine Co., Hillside, N. J., produces plastic part shown below.

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BASIC ANALYSIS

Carbon 0.50 Manganese 1.00 Silicon 0.30
Chromium 1.10 Molybdenum 0.25
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Lustre-Die is such a clean, clean steel. It is carefully inspected to ensure freedom from porosity or surface pitting. Machining is easy, too, as the steel is free from nickel. Besides, there are no additives to cause inclusions, which could cause spotty areas on the die surface.

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BETHLEHEM TOOL STEEL ENGINEER SAYS:

Unusual Metal "Pickup" on Tools Is Caused By Carburization

Metal "pickup" occurring on the surface of tools used in shearing, blanking or forming metal can be an annoying problem. When such "pickup" is routine and expected, it is customary to provide continuous maintenance to remove the adhering metal. But when it suddenly occurs in an operation normally free from "pickup," the trouble can be serious.

Recent investigations have shown that the most common cause of unusual "pickup" on tools is the unsuspected presence of an unwanted carburized case, unintentionally placed on the tools during heat-treatment, and therefore not removed by grinding after heat-treatment. On many grades of tool steel, a high carbon case causes retained austenite to form during heat-treatment. As the austenite is very soft, its presence on the surface of otherwise hard tools is sufficient reason to account for metal "pickup." A regrinding operation on the tool usually removes the austenitic skin, eliminating the trouble.

GOOD RESULTS WITH 66 HS

Bethlehem 66 HS (High-Speed) tool bits can always be counted on for smooth, steady cutting. In the operation illustrated, the 66 HS bit is shaping a bending die. 66 HS, because of its well-rounded 6-5-4-2 analysis, has all the properties needed for economical high-speed work.

Hardenability . . .

notched strengths than nickel or nickel-chromium-molybdenum steels when all were heat treated to unnotched strengths between 220,000 and 250,000 psi. This was due to a difference in ductility at the higher strengths. Similar differences appear in impact tests of various 0.40% C alloy steels, heat treated to the same hardness and tested over a range of temperatures.

When the notch toughness of heat treated alloy steels is evaluated on the basis of transition temperature, or the temperature giving Charpy values of 10 to 15 ft-lb., great differences between various martensitic alloy steels similarly tempered can be shown. An example is presented of a complex alloy steel tempered at 400° F. which had 12-ft-lb. Charpy value at –200° F. Chromium or manganese steels similarly heat treated would not be as tough at temperatures up to 300° F.

The comparisons given above apply to steels quenched to a fully martensitic structure, but most steels in actual practice are "slack quenched" to a structure more or less contaminated by transformation products. The transition temperatures of such steels were found to be higher than when the quench was not slack, although the tempered hardness was the same. Furthermore, slack quenching increased the differences in transition temperature between the different alloy steels, the influence of the alloy content being greater than when the quenched structure was fully martensitic. The particular alloy in the steel is therefore important under the conditions of actual practice.

For steels heat treated to equal strength, a decrease in carbon content in the range from 0.80 to 0.40% improves the ductility and lowers the transition temperature. In low-carbon normalized steel, however, the transition temperature is lowered by manganese. Whether these effects are due to changes in microstructure or to changes such as dislocations in the ferrite matrix is not known at present. (*Continued on p. 200*)

Hardenability . . .

The effect of retained austenite on the transition temperature of a heat treated complex alloy steel was investigated for the final section of this lecture. This steel contained 0.38% C, 0.77% Mn, 1.57% Si, 1.82% Ni, 0.84% Cr, 0.32% Mo, 0.07% V and 0.027% Al. It was quenched in oil and cooled to –320° F. to produce 2.5% austenite; quenched with a 25-min. arrest at 390° F. to give 5%; and with a 1-hr. arrest at 440° F. to give 10%. After tempering at 400° F., the hardness values were C-54.5, 53.5 and 52, respectively. The microstructures were identical, revealing no bainite from the quenching arrests. Charpy impact tests over a range of temperature on these specimens gave very similar curves, but with slightly lower values for 2.5% austenite. The 15-ft-lb. transition temperature was about –130° F. for 2.5% austenite and about –150° F. for 5 to 10%.

It is concluded from the data presented that the mechanical properties of the triple alloy Ni-Cr-Mo steels, which make the most efficient use of the elements promoting hardenability, are in general superior to the properties of the double or single-alloy steels.

G. F. Comstock

Ceramics for Metal-Cutting Tools

Digest of "Ceramics for Metal-Cutting Tools", by W. B. Kennedy. American Society of Tool Engineers Preprint No. 24T1, 1956.

Exploratory tests on ceramic cutting tools at Watertown Arsenal indicate that their extreme brittleness may not be the glaring deficiency many technical and shop personnel have feared it would be. Tool materials studied experimentally include glass-bonded aluminum oxide, high-purity aluminum oxide, aluminum oxide with various additives, metal-bonded silicon carbides and boron carbides. Results showed that only those processed from aluminum oxide had appreciable ability to machine steel while ceramic tools capable of machining steel displayed equal or superior performance in machining cast iron or brass.

In one instance, a high-purity aluminum oxide lathe tool removed 709 cu. in. of metal from an 8-in. diameter shaft of annealed S.A.E. 1045 bar stock. It was machined at a rate of 1560 surface ft. per min. Although significant edge wear was evident, there was no indication of cratering on the top face.

High resistance to abrasion of a ceramic tool was demonstrated during the machining of a 5-in. diameter low-alloy cast iron test bar with the tool cutting through abrasive scale without difficulty. Also, a sand inclusion about ¾ in. across and ⅛ in. deep was machined off with no effect on the tool and no evidence of "bumping" on the lathe cross slide. The high cutting speeds used are of interest from the production standpoint since these speeds are considerably higher than those normally used with conventional cutting tools.

Various types of toolholders were evaluated and it became apparent that the best design was one which

Cutting Tools . . .

gave maximum support to the ceramic tip since the type of failure experienced was a complete fracture at the cutting edge. In general, four requirements must be met by toolholders for ceramic tips:

1. Substantial cross-section area in the shank.
2. Seating and clamping design which assures evenly distributed forces on the tool.
3. Adjustable mechanical hard metal (carbide) chipbreakers.
4. Tool design which provides minimum overhand deflection.

Attempts to braze ceramics to steel holders with metal solder were unsuccessful. A thin layer of copper, deposited on the ceramic tip by a metal spray gun, failed to adhere to the ceramic when heated to the brazing temperature of the silver alloy solder. Examination of the steel shank disclosed that the copper had united with the solder, leaving the ceramic free.

Further investigation indicated that it is possible to hold a ceramic cutting tool in a steel shank by mechanical means. This is done by machining a recess in the holder to dimensions slightly smaller than the tip and then heating it to develop enough expansion to permit seating the tip. Organic or metal bonding agents are applied to the heated shank before inserting the tip and allowing the assembly to cool. Difficulty with this technique is its high cost because of the precise machining necessary on the holder.

Excellent heat resistance of the ceramic specimens permitted dry grinding without difficulty. Chipping of the cutting edge occurred frequently when grinding with silicon carbide wheels, but this was overcome by a change to standard diamond-impregnated wheels of 150 and 350 grit, which produced a lustrous surface on the tool. Careful hand honing of the cutting edge with a 350-grit diamond-impregnated hone was necessary to prevent flaking by contact with the curling chip and to diminish the tendency of the edge to chip in operation.

Experiments with applications involving interrupted cutting or impact machining, such as milling, did not meet with much success. However, speeds did not exceed 800

Cutting Tools . . .

surface ft. per min. Possibly at speeds of 1500 surface ft. per min. or higher better results would have been obtained. At these speeds grain distortion on the surface of the workpiece is considerably reduced and the cutting action is easier.

While the tests herein reported were limited to finishing and light roughing cuts on a lathe, the conclusion was reached that ceramic cutting tools have definite possibilities. Obviously, further investigational work needs to be done, both on presently available and untried varieties of ceramics and on their most efficient application to conventional tool shapes.

Arthur H. Allen

Elimination of Flakes in Large Forgings

Digest of "Rational and Economical Annealing Process for Drop-Forged Blanks of Steel 5KhNT", by N. A. Timchenko, *Metallovedenie i Obrabotka Metallov*, No. 4, 1955, p. 32-38.

The main problem was flaking. This problem arose when a new steel, 5KhNT, was introduced by the Russians to replace 5KhGM. Both had 0.5 to 0.6% carbon, but the new steel had about 0.7% manganese, 1.0% chrominum, 1.5% nickel and 0.2% titanium, while the old one had 1.4% manganese, 0.7% chromium, no nickel and 0.2% molybdenum. Even though a long (300 hr.) and complex annealing process was employed, it was found that blanks larger than 14 × 14 in. tended to develop flakes and also had a coarse grain structure in the center.

In order to design an improved annealing cycle, data of various kinds were obtained. First, the isothermal decomposition diagram of the steel was determined and it was found that the highest rate of austenite decomposition occurred near 1200° F. Next, the hardness values existing after isothermal annealing were investigated and it was found that the lowest hardnesses were produced by annealing for 3 hr. or longer at about 1200° F. The corresponding microstructure was a mixture of fine pearlite and small

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Flakes . . .

grains of ferrite, the amount of ferrite increasing with increase in the time of annealing. A supplementary study showed that still lower hardness could be obtained if the blanks were air cooled from the austenitizing temperature to about 750° F. prior to annealing at 1200° F.

On the basis of these results the following annealing cycles were proposed:

1. For blanks less than 14 × 14 in., cool to 570° F. after forging, anneal immediately at 1200° F. for 50 hr. and then cool in the furnace to 750° F.

2. For blanks from 14 × 14 to 20 × 20 in., cool to 750° F. after forging, heat at 1600° F. for 9 hr., air cool to 480° F. and hold for 5 hr., heat at 1200° F. for 30 hr. and furnace cool to 750° F. Cooling from the austenite range not only produced minimum hardness but also was helpful in eliminating hydrogen from the steel.

Trials of the above cycles were made on blanks forged at an initial temperature of 2000° F. and finished at 1550° F. The Brinell hardness was 229, no flaking was observed and the microstructure was fine throughout the cross section. It was verified that the simpler cycle was not adequate for sections larger than 14 × 14 in. A. G. Guy

Sheet Metal Forming in England

Digest of "The Deep Drawing and Spinning of Sheet Metal, With Particular Reference to Non-Ferrous Materials", by J. A. Grainger, *Journal* of the Institute of Metals, Vol. 84, February 1956, p. 133-146.

In deep drawing, the design of the press tools is of primary importance. To form a cylindrical cup from a flat sheet successfully, the radius on the die edge and the clearance between punch and die must be adjusted for each material and cup depth. For a very shallow cup, a short edge radius and restricted clearance are required to obtain straight sides in the cup. If the drawn cup is long, the clearance must be increased to allow for thick-

Sheet Forming . . .

ening of the drawn material at the mouth and to prevent the ironing load from exceeding the strength of the cold worked metal. The surface of the die and punch must be extremely smooth when the weaker nonferrous alloys are drawn. It is even more important to have the top and sides of the die accurately tangential to the curve of the edge.

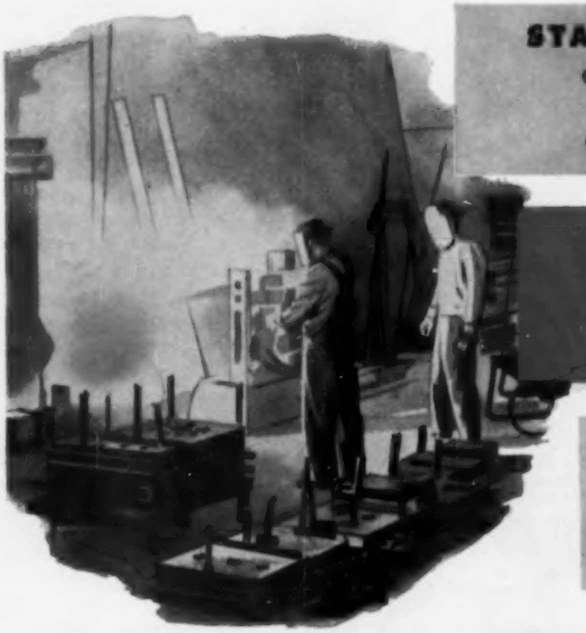
In drawing a rectangular shape, true drawing occurs only at the corners and edges, and the bedding pressure at the corners of the blank must be precisely controlled to prevent wrinkling or tearing. For severe drawing in several stages, the corners of the shape formed in the first draw should have a larger radius than in the finished shape. In the second draw the corner may have a radius 30% less than that in the first. Flanges may have to be squared or set after annealing following a severe multiple draw. In redrawing the nonferrous metals the edge of the die should have an included angle of 60°.

Ordinary crank presses do not perform at the most desirable speed because, although the slowest motion occurs at the start of the stroke, the actual drawing of the blank begins at midstroke when the punch is moving too fast. Hydraulic presses, especially those with variable speed, are more suitable. A modern crank press has been constructed to start the actual drawing at about half the maximum speed which is a notable improvement. In such a press the table or bed rises as the punch comes down so that an 11-in. draw can be made with a press stroke of less than 15 in.

A series of drawing tests with copper sheet showed that with no lubricant, drawing pressure rose about 10% as the blankholding pressure rose from 74.7 to 747 psi. With plain oil the results were about the same. With molybdenum disulphide in the oil the drawing pressure was distinctly lower and virtually constant. All the copper blanks reached about the same final hardness with any blankholding pressure.

To save the time and expense of making female dies, blanks can be pressed against a confined rubber pad with a punch having the same shape as the inside of the article be-

WAUKESHA casts all 3



STAINLESS STEEL

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Group II — Ferritic
Group III — Austentic

NON-FERROUS

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Brass and Bronze, Aluminum
Everdur, Aluminum Bronze

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Especially is this so where there is a critical corrosion-resistant casting design problem combined with one of hardness, or strength, elongation, wear resistance, bearing qualities, impact, scale resistance, seizing or galling, or intergranular corrosion among others.

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Metallurgical laboratory control guarantees you castings that are uniform, close-grained, free of porosity, metallurgically accurate in composition, and dimensionally correct—real assets to your products.

We suggest that you write for a casting quotation or engineering counsel.

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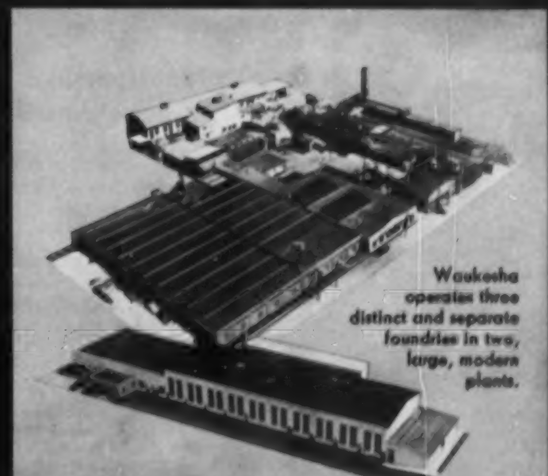


WAUKESHA—SPECIALISTS IN CORROSION-RESISTANT CASTINGS FOR ALL INDUSTRIES

Sheet Forming . . .

ing formed. A steel pressure plate is forced up around the punch to support that part of the blank not in contact with the punch and to prevent wrinkling. Hydraulic presses of high capacity are required since the punch must not only draw the blank and press it against the rubber, but must also press the rubber and flange against the pressure plate.

Hydroforming is similar but requires a different kind of machine. Instead of a solid rubber block, hydraulic pressure up to 15,000 psi. is used against a rubber diaphragm. A pressure dome is locked above the rubber and blank to be formed and the forming punch is forced up against the blank. The pressures above and below the blank are carefully controlled. The metal is thinned very little and large deformations are obtainable with comparatively simple tools. It is most suitable for producing a few parts of a given kind. Undercut forms can be produced by having loose pieces on the punch and removing them from the formed article after the punch is withdrawn. Some intricate shapes are formed with an extra sheet of rubber between the blank and the main diaphragm so as to prevent cutting the diaphragm.

Spinning of a rotating disk in a lathe to form a hollow shape requires only a male die and a piece of hard wood as a pressing tool, but the operator must have considerable skill. Excessive thinning may be avoided by annealing between stages. Improved lathes with roller tools have been developed to reduce the operator's fatigue. Metals vary in their ability to be spun, and shapes easily drawn are not necessarily easy to spin.

Flow forming is a modification of spinning in which thick material is made to flow by pressure rolling, with a reduction in thickness up to 75%. This process requires very sturdy lathes and hydraulic power for holding the blanks. The diameter of the blank is not changed as it is in spinning. Conical shapes are most easily flow formed but cylinders can be formed in a single pass by first cupping and then flowing with a specially designed roller.

G. F. Comstock

Weldability of Some Mn-Ni-Cr-Mo Steels

Digest of "The Weldability and Mechanical Properties of a Series of Mn-Ni-Cr-Mo Steels", by C. L. M. Cottrell, B. J. Bradstreet and T. E. M. Jones, *British Welding Journal*, Vol. 3, March 1956, p. 90-98.

INVESTIGATION of the crack sensitivity of high-alloyed steels welded with low-hydrogen electrodes should indicate steel compositions which would combine a much higher proof stress with good weldability. A series of 31 Mn-Ni-Cr-Mo steels were made up and tested in the normalized condition. To assess weldability, the controlled thermal severity test was used with thermal severity numbers of 10 to 6. One week after welding, three transverse sections were taken from each weld. Each section was polished, etched and examined under the microscope for cracks in the heat-affected zone. In addition, a hardness exploration was made on one section of each weld.

The safe upper limit of hardness in the heat-affected zone is just over Vickers 400. High-temperature cooling rate is responsible for hardness and low-temperature cooling rate governs the extent of cracking. The tests indicated that the best combination of weldability and mechanical strength is obtained with a multiple-alloy steel with 0.11 to 0.15% carbon, 1.1 to 1.4% manganese, 1.0 to 1.2% nickel, 0.9 to 1.1% chromium and 0.20 to 0.25% molybdenum.

Weldability tests were made on this steel using thermal severity numbers of 10 and 6. With low-hydrogen electrodes, cracking occurred with cooling rates of about 35° F. per sec. at 570° F. but not with cooling rates less than 150° F. per sec. or more than 60° F. per sec. This critical cooling range for low-hydrogen electrodes has been encountered in previous work and may be due to low transverse stress or abnormally short time intervals during which hydrogen can diffuse from the weld into the heat-affected zone.

Dilation tests were made on small specimens using high-frequency induction heating and gas quenching to simulate the thermal cycle in a weld heat-affected zone. A continuous cooling time-temperature-transformation diagram was produced for the steel for the range of cooling rates normally encountered in welding. Using the critical cooling rates determined by weldability tests, it was found that corresponding 50 and 100% critical transformation temperatures for hard-zone cracking can be obtained. These will be the lowest temperatures for the occurrence of transformation consistent with freedom from cracking.

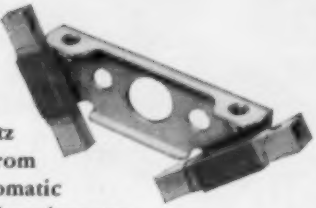
On the basis of these tests, the authors conclude:

1. The best combination of weldability and strength is obtained in a multiple-alloy steel of low carbon content.
2. The safe limit of hardness in the heat-affected zone of low-alloy steels to avoid cracking is just over Vickers 400 for low-carbon steels and approximately 45 for higher carbon steels when welding with low-hydrogen electrodes.

H. J. NICHOLS

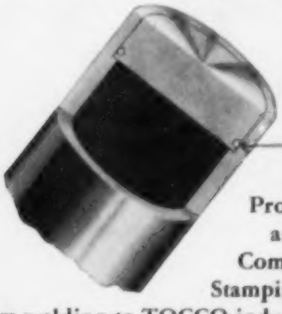
7 WAYS to SAVE MONEY with TOCCO* Induction Brazing

1



$15.84 per hour was saved by Jack & Heintz when they switched from torch brazing to automatic induction brazing of these inverter brush mounts. TOCCO brazing also upped production from 40 to 360 brazed assemblies per hour.

2



Production was doubled and cost cut 50% when Commercial Shearing and Stamping Company changed from welding to TOCCO induction brazing of these hydraulic cylinder assemblies. Heating time was cut from 15.3 minutes to 2 minutes on 5¼" cylinder shown here.

3

Willey's Carbide Tool Co. cut cost of brazing tips on large lathe tools from 58¢ to 4¢ when they adopted TOCCO induction brazing. Production is 8 times as fast with TOCCO—85 per hour, against 80 per day produced by a former method.

4

Formerly, Norris Thermador Corporation used arc welding to join this bushing and clamp. The change to TOCCO induction brazing reduced their costs 32%—from $46.44 to $31.73 per thousand parts.

5

When Mechanics Universal Joint Division of Borg-Warner shifted from welding to TOCCO induction brazing of this drive shaft assembly, they reduced the cost of the operation 67%. At the same time automatic TOCCO increased production from 11 to 45 pieces per hour—400% faster than the former method.

6

Packard engineers saved $1.74 per part when this automatic transmission shaft was redesigned from a forging to a steel shaft and casting, permitting the use of TOCCO induction brazing. In addition to this per part saving, $74,325 was saved in equipment and tooling.

7

Number 7—the lucky number—is up to you. Why not add your name to the list of companies who use TOCCO Induction Heating to increase production, improve products and lower costs. TOCCO engineers are ready to survey your plant for smililarly money-saving results—without obligation, of course.

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Please send copy of "Typical Results of TOCCO Induction Brazing and Soldering."

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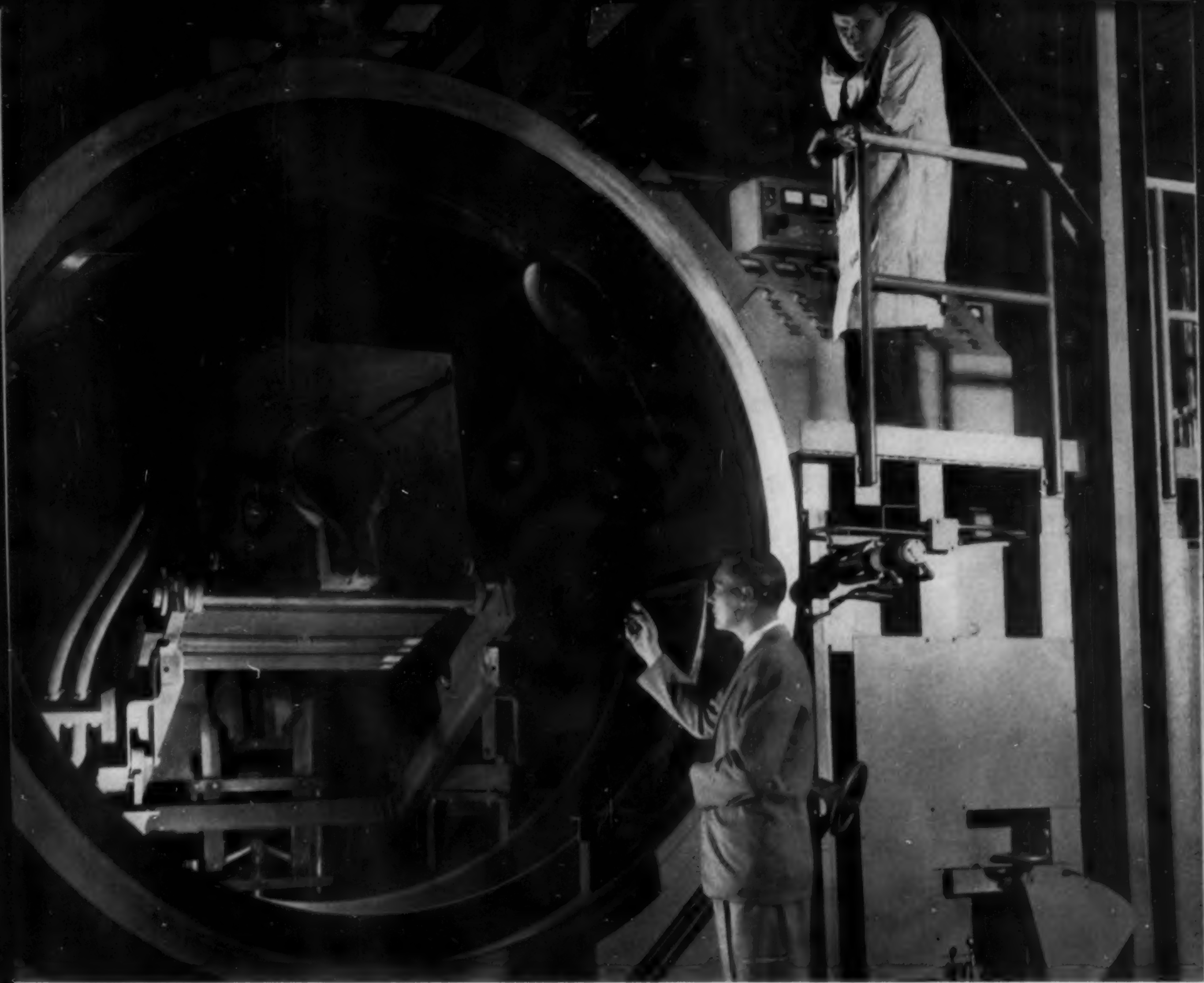

Incorporated within vacuum chamber is a rail-mounted ingot mold carriage, which passes through the vacuum lock, moves into position to receive the heat of processed metal and then carries it out on to the mold storage floor. Vertically-hinged door swings fully open, permitting unobstructed access to interior of furnace.

The metals industry is profiting from the use of other STOKES production equipment

Vacuum Metallizers. Stokes offers a complete line of vacuum metallizing equipment to plate metals for improved surface finish . . . also to provide conductive coatings on non-conductive materials.

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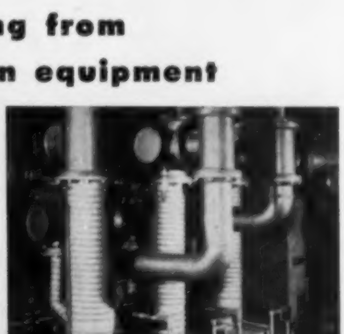

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The lady of the house knows a good thing when she sees it, and for this very reason more products for the home are being fashioned of Sharon Stainless Steel.

Housewives recognize the many advantages of things stainless. The rich, lustrous beauty that never fades or tarnishes; the gleaming, dense surface that wipes clean with a damp cloth; and ruggedness that absorbs punishment without marking.

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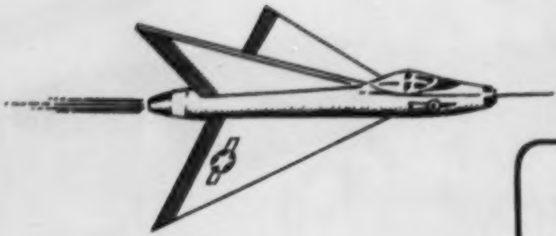

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EXTRA CAPACITY

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Exclusive P&H design features permit handling greater positioning loads for every dollar you invest

Positioned welding is *downhand* welding, that permits your weldors to use larger, hotter rods for higher deposition rates. This extra welding speed and the savings in handling of weldments cut welding costs as much as 50%.

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This extra-capacity advantage is found in all sizes of P&H positioners. A free load-capacity table is available to help you select the model best suited to your needs. Just send in the coupon.

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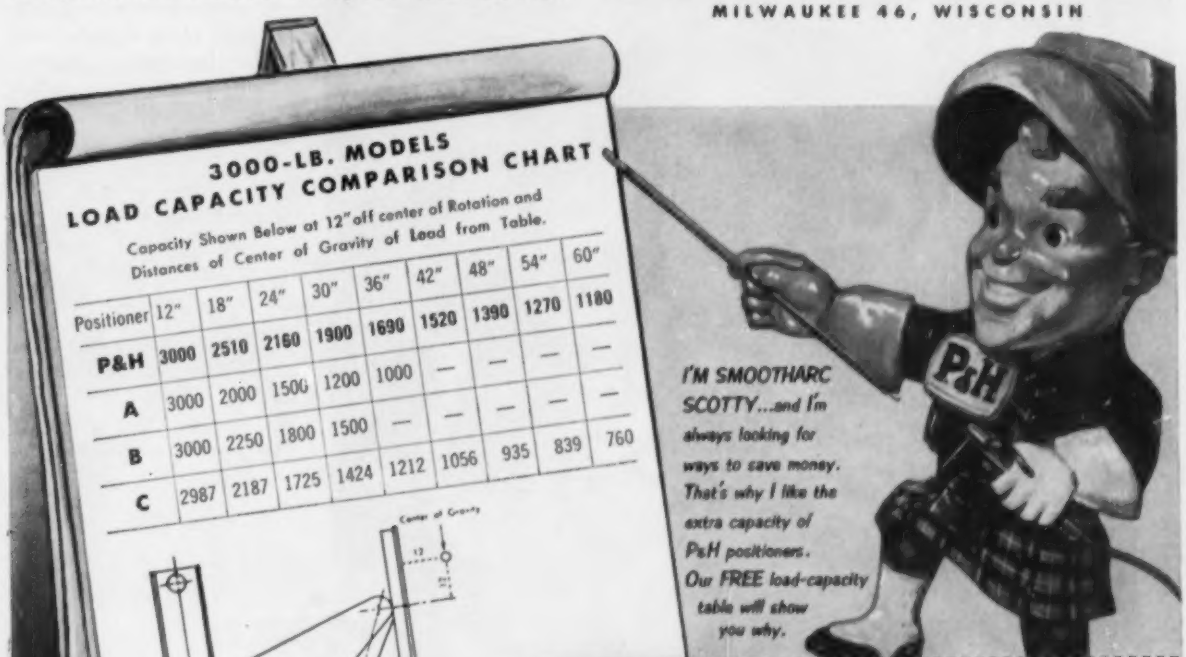

Positioner	12"	18"	24"	30"	36"	42"	48"	54"	60"
P&H	**3000**	**2510**	**2160**	**1900**	**1690**	**1520**	**1390**	**1270**	**1180**
A	3000	2000	1500	1200	1000	—	—	—	—
B	3000	2250	1800	1500	—	—	—	—	760
C	2987	2187	1725	1424	1212	1056	935	839	

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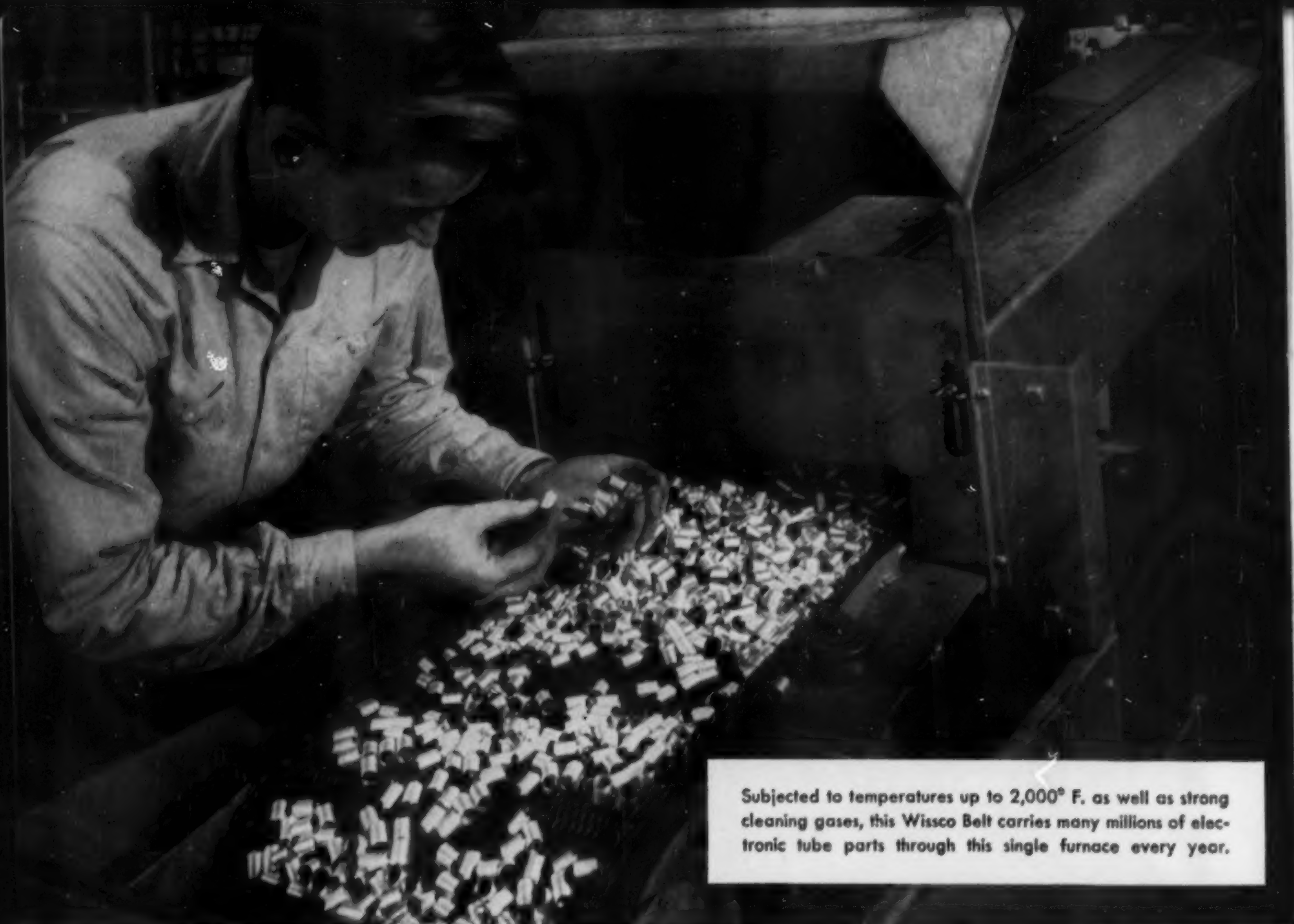
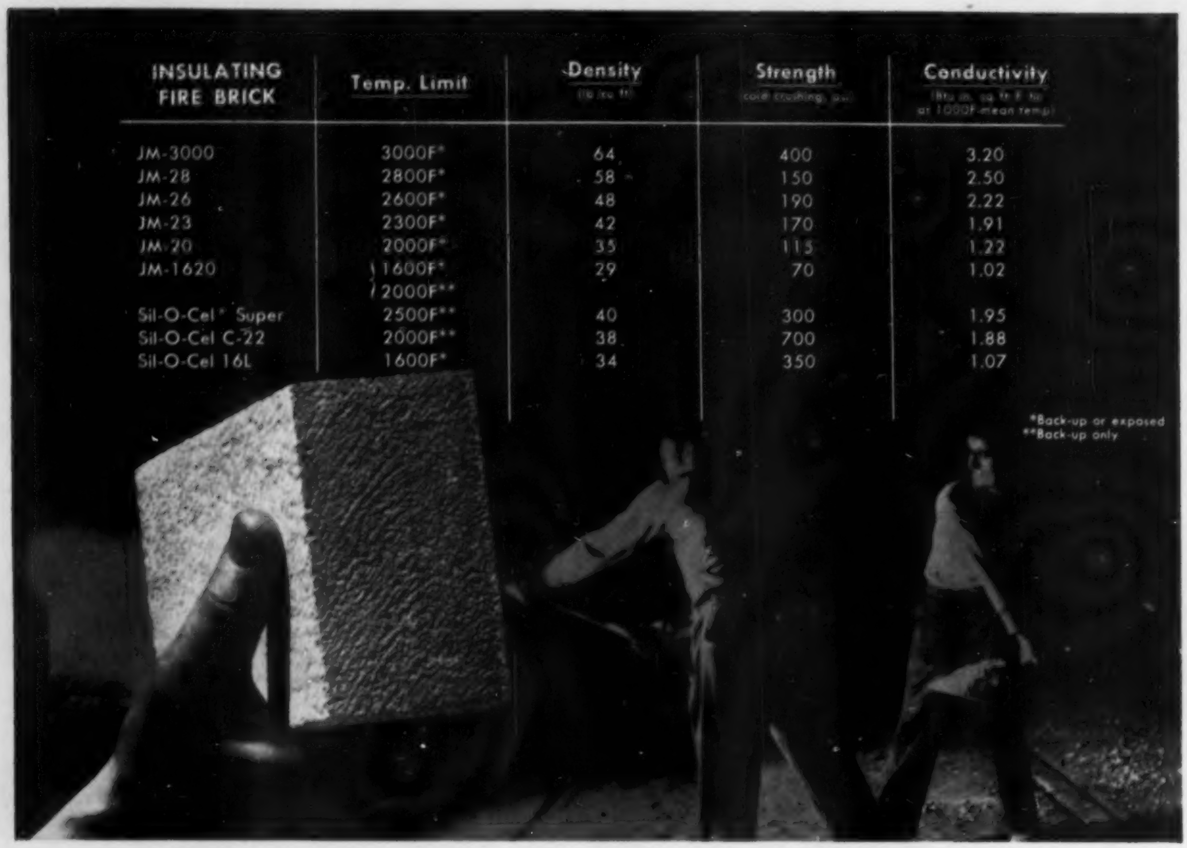
3000

the **P&H** *Line*

P&H welding equipment is manufactured and sold in Canada by REGENT EQUIPMENT MANUFACTURING COMPANY LTD., 455 King Street West • Toronto, Ontario, Canada



Subjected to temperatures up to 2,000° F. as well as strong cleaning gases, this Wissco Belt carries many millions of electronic tube parts through this single furnace every year.



INSULATING FIRE BRICK	Temp. Limit	Density (lb cu ft)	Strength (cold crushing, psi)	Conductivity (Btu in. sq ft F hr at 1000F mean temp)
JM-3000	3000F*	64	400	3.20
JM-28	2800F*	58	150	2.50
JM-26	2600F*	48	190	2.22
JM-23	2300F*	42	170	1.91
JM-20	2000F*	35	115	1.22
JM-1620	1600F* / 2000F**	29	70	1.02
Sil-O-Cel* Super	2500F**	40	300	1.95
Sil-O-Cel C-22	2000F**	38	700	1.88
Sil-O-Cel 16L	1600F*	34	350	1.07

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From Johns-Manville refractory research...

insulating fire brick with balanced properties for unsurpassed heat-control effectiveness

The nine types of insulating fire brick produced by Johns-Manville offer furnace builders and operators a common advantage—*balanced properties!*

The Johns-Manville insulating brick formulated for your service gives you the ideal combination of physical and thermal properties without sacrificing one for the other. This means you get unsurpassed heat-control effectiveness . . . greater economy in furnace design . . . hours saved in reaching operating temperatures!

For a good example of the value of *balanced properties*, take the proved performance of JM-3000 insulating fire brick. Formulated for 3000F temperature service, this insulating fire brick has unusual load bearing strength, high spall resistance, low shrinkage and thermal conductivity proportionate to its density.

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For complete information, call your nearest J-M representative. Or write for brochure IN-115A to Johns-Manville, Box 14. New York 16, N. Y. In Canada, Port Credit, Ontario.

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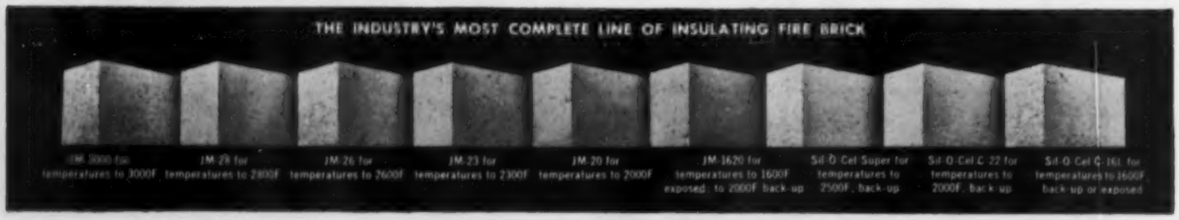
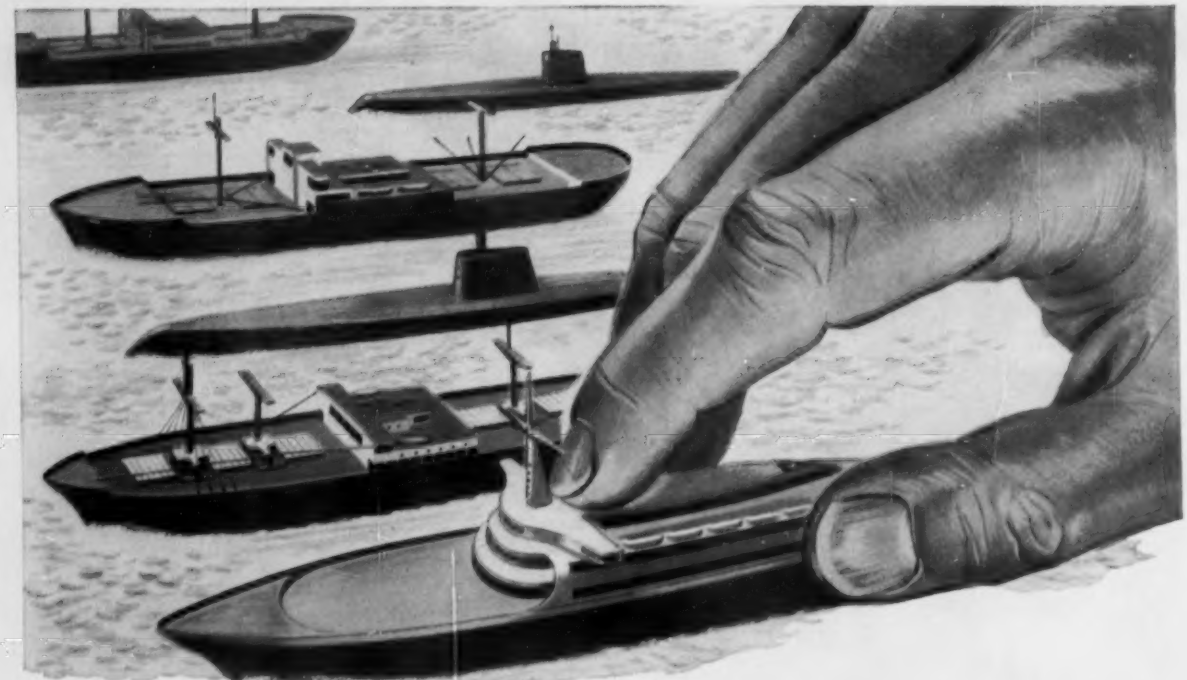


METALLURGISTS...



Help develop the world's first nuclear powered fleet

Nuclear power offers tremendous advantage for naval vessels. From the fuel standpoint, cruising ranges are virtually unlimited—even at new high speeds. No refueling facilities will be required to replenish nuclear propulsion fuel. Therefore, the physical design of the fleet can be streamlined for greater efficiency and safety.

At the country's largest design-engineering center for nuclear power reactors, Bettis Plant in Pittsburgh, operated for the Atomic Energy Commission by Westinghouse, the application of nuclear power has progressed rapidly. However, the nuclear power plants already in operation today represent only the beginning of a new technological era. *Major advances in many areas are necessary.*

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Atomic experience is not necessary.

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Educational opportunities are exceptional. Westinghouse helps you continue your studies at any one of three Pittsburgh universities.

Write for descriptive brochure on opportunities in your field. Be sure to specify your interests. Address Mr. A. M. Johnston, Westinghouse Bettis Plant, Dept. A98, P.O. Box 1468, Pittsburgh 30, Pa.

BETTIS PLANT
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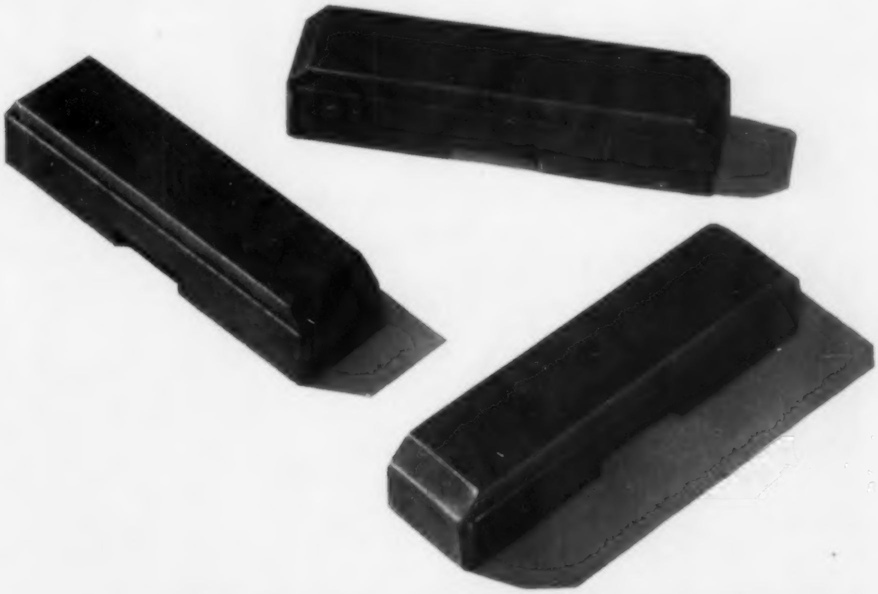
Costs cut 50% on these stainless steel castings



COOPER ALLOY SHELLCAST® PROCEDURES AND ADVANCED KNOW-HOW MAKE A TOUGH JOB EASY

These stainless steel defibering blades are used by E. D. Jones & Sons, Pittsfield, Mass. on the Hi-speed rotor of their unique Hi-Lo Pulper, a new advance in better and faster pulp and paper defibering.

To achieve highest efficiency, E. D. Jones required these blades to have dimensional accuracy (± .005 in.), a fine smooth surface free from defects, clean sharp edges and impact resistance to metallic impurities at velocities of 7,000 fpm.

The production method previously used was to machine them entirely from bar stock. Through use of the Cooper Alloy Shellcast® method and shell coring procedures to obtain high quality and accuracy, these blades were cast by Cooper Alloy at a savings of 50%.

As a result of Cooper Alloy Advanced Know-How, another difficult stainless steel casting has become a standard production job.

For further information, write for Bulletin AKH#5.

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Foundry Products Division

In wrought Inconel "Neu-pot", KLK Manufacturing Company, Logansport, Indiana, treats small parts faster. For information about the "Neu-pot" write Rolock, Inc., Fairfield, Connecticut.

Treated in wrought Inconel pots, these small parts cost less

volume goes up, pot replacement down

These parts are done to a turn . . . in nice time, at low cost.

That's because the salt bath is contained in a Rolock "Neu-pot" made of wrought Inconel* nickel-chromium alloy.

KLK Manufacturing Company reported that unlike most "pot" materials, Inconel alloy retains original heat transfer characteristics throughout its useful service life. With it, loads can be hurried along as rapidly as good practice permits. Volume goes up, cost per piece down.

Long pot life lowers cost, too

In this installation, KLK goes on to say, Inconel nickel-chromium alloy also substantially increases pot life. They report that former pots gave, at best, only six weeks service. Their first Inconel "Neu-pot" lasted almost 5 times longer.

In overall pot expense KLK saves 50 percent by using wrought Inconel alloy. The company also realizes a major reduction in down-time. Both savings are reflected in the cost per piece.

Is high sustained heat, or heat plus severe corrosive conditions your problem? If so, look into Inconel. Write for the Inco booklet, "Keep Operating Costs Down As Temperatures Go Up."

*Registered Trademark

The International Nickel Company, Inc.
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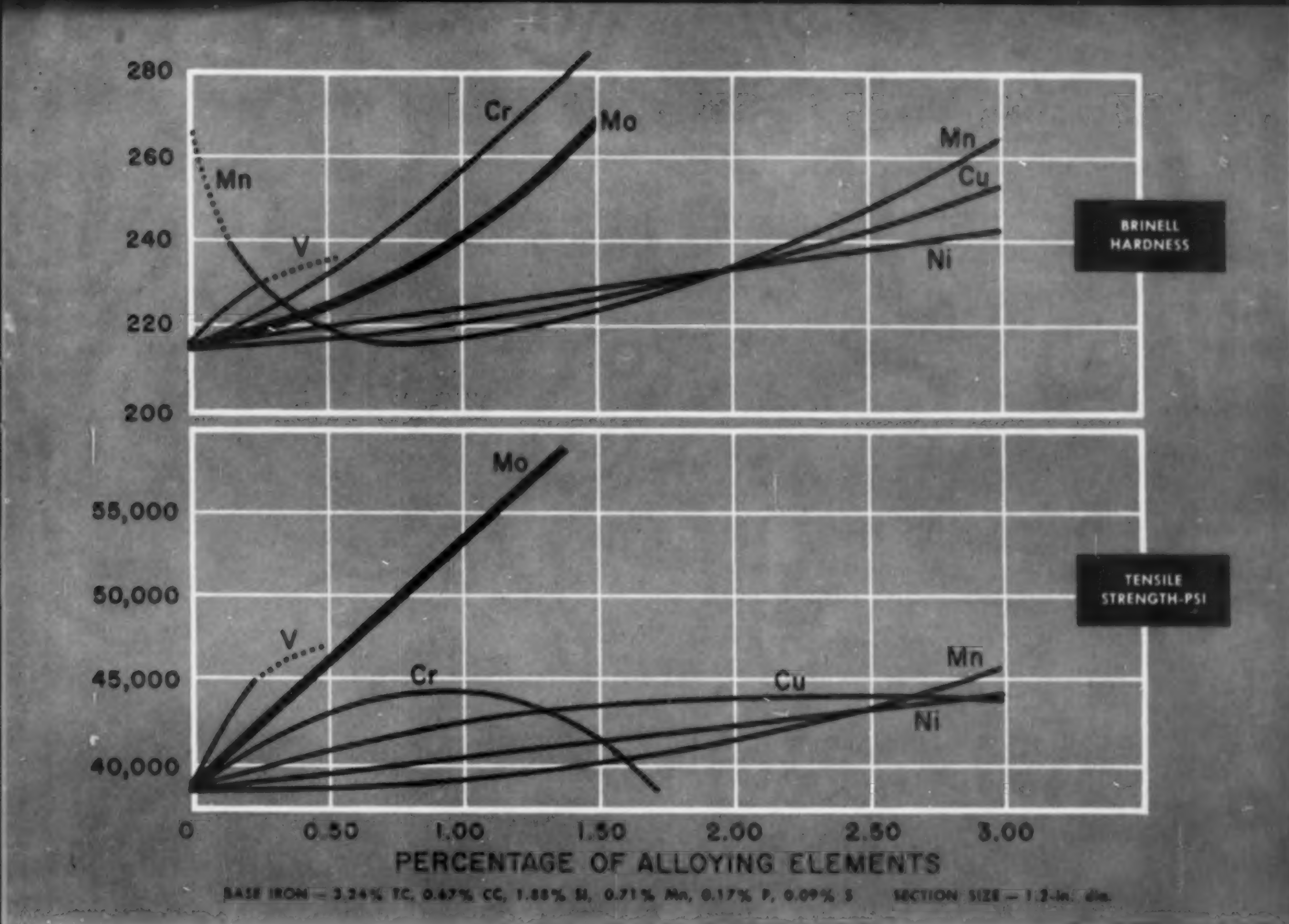
Inconel . . . *for long life at high temperatures*



Note how additions of moly, up to 1.5%, produce proportional improvements in strength. And, with moly, hardness increases much more slowly. It means higher strengths can be used with less danger of impaired machinability.

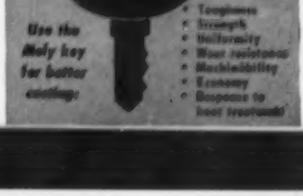
each ½% Moly adds 7000 psi to strength of cast iron...

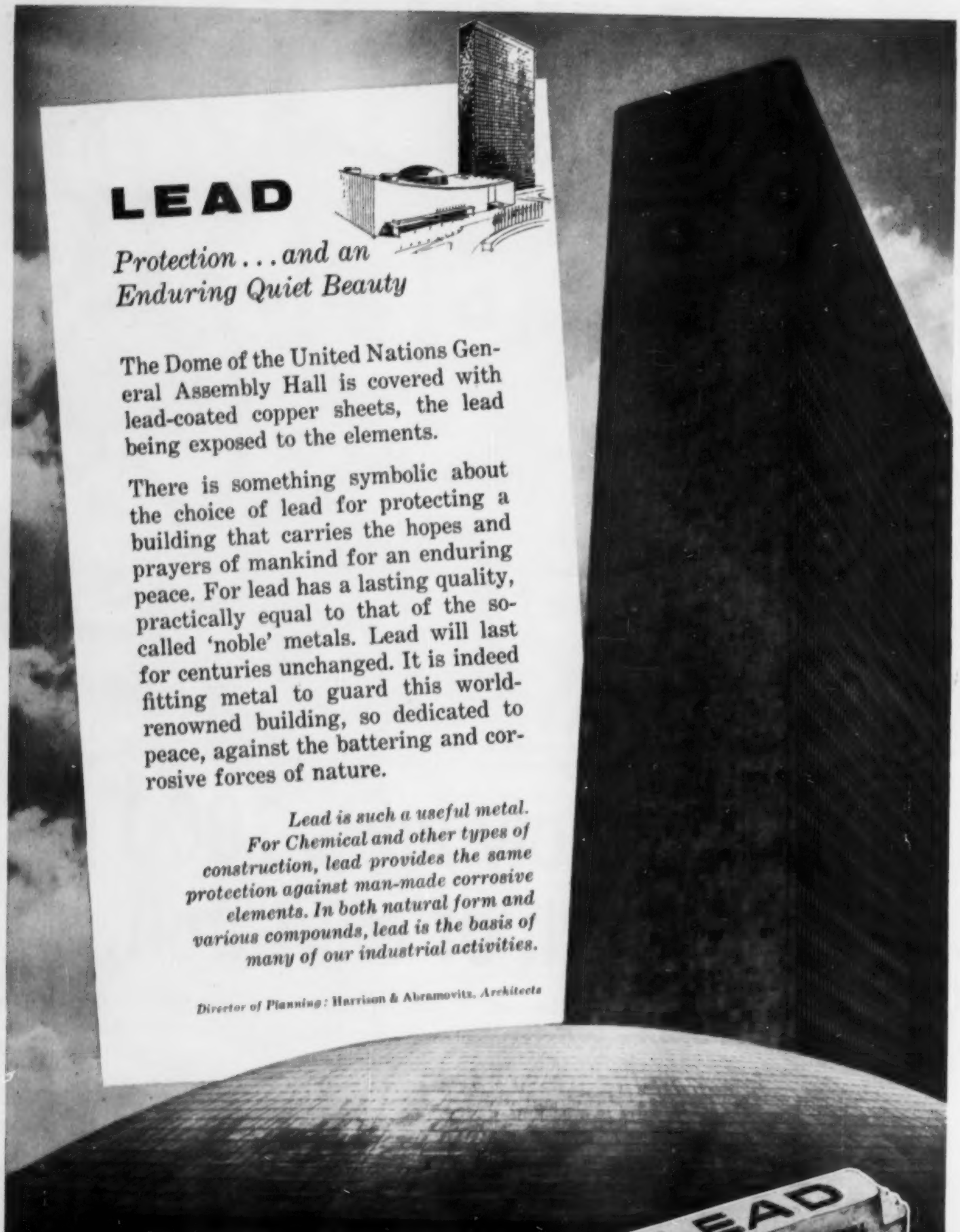
A little moly adds a lot of strength – for molybdenum increases strength more than any other common alloying element, with the exception of small vanadium additions. A rule of thumb is that fifty points of moly raise tensile strength 7000 psi. And without sacrificing toughness. Actually, moly improves toughness at least as much as strength.

What's more, versatile moly aids in obtaining uniform response to heat treatment . . . and in producing machinable, growth-resistant castings. Moly is easy to use, too. With most grades of cast iron, moly requires no change in the character of the charge, normal melting practice, or the base metal. And foundrymen like the fact that the small additions necessary may be made at the spout or in the ladle.

Write now for "Why Moly Iron". It's the full story of how and why moly adds strength faster than hardness, how it increases fatigue and torsional strength—in short why moly makes better cast iron. Climax Molybdenum Co., Dept. 5, 500 Fifth Avenue, New York 36, N. Y.

CLIMAX MOLYBDENUM





LEAD
Protection . . . and an Enduring Quiet Beauty
The Dome of the United Nations General Assembly Hall is covered with lead-coated copper sheets, the lead being exposed to the elements.
There is something symbolic about the choice of lead for protecting a building that carries the hopes and prayers of mankind for an enduring peace. For lead has a lasting quality, practically equal to that of the so-called 'noble' metals. Lead will last for centuries unchanged. It is indeed fitting metal to guard this world-renowned building, so dedicated to peace, against the battering and corrosive forces of nature.
Lead is such a useful metal. For Chemical and other types of construction, lead provides the same protection against man-made corrosive elements. In both natural form and various compounds, lead is the basis of many of our industrial activities.
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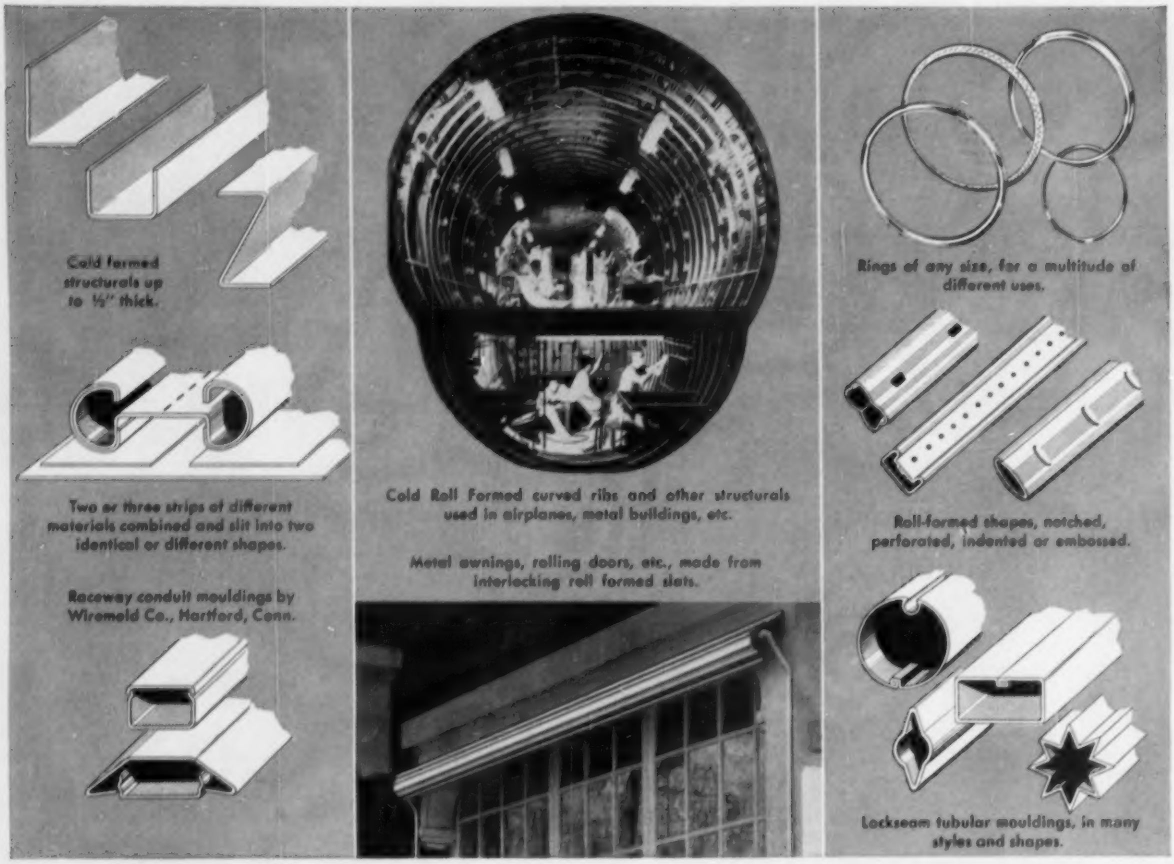

Cold formed structurals up to ½" thick.

Two or three strips of different materials combined and slit into two identical or different shapes.

Raceway conduit mouldings by Wiremold Co., Hartford, Conn.

Cold Roll Formed curved ribs and other structurals used in airplanes, metal buildings, etc.

Metal awnings, rolling doors, etc., made from interlocking roll formed slats.

Rings of any size, for a multitude of different uses.

Roll-formed shapes, notched, perforated, indented or embossed.

Lockseam tubular mouldings, in many styles and shapes.

1001 Things Now Being Done By COLD ROLL FORMING

• The basic function of a Yoder cold roll forming machine is, of course, to convert flat rolled strip or sheets at high speed into mouldings, panels, tubular, channel and other shapes.

Quite often, these shapes need further elaboration before being ready for assembly or installation. They may, for instance, have to be curved, coiled or made into rings. Or they may need to be perforated at certain intervals of spacing, notched, embossed, or otherwise finished by additional operations. You may want to combine two or more materials into a finished shape, such as carbon steel with stainless, felt, wood, etc.

These and many other things can be done with Yoder machines at little or no extra cost over and above normal conversion costs, simply by providing special attachments, or by auxiliary units installed in line with the forming mill.

So, to the recognized high economy of the cold forming operation itself, other important production economies may be added. Yoder engineers are at your service in designing equipment of this kind.

The Yoder Book on Cold Roll Forming is a complete text, profusely illustrated, on the art and its scope, the machines, their tooling and application to a multiplicity of mass production needs. A copy is yours for the asking.

THE YODER COMPANY • 5595 Walworth Ave., Cleveland 2, Ohio

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COLD ROLL FORMING MACHINES

ROTARY SLITTING LINES

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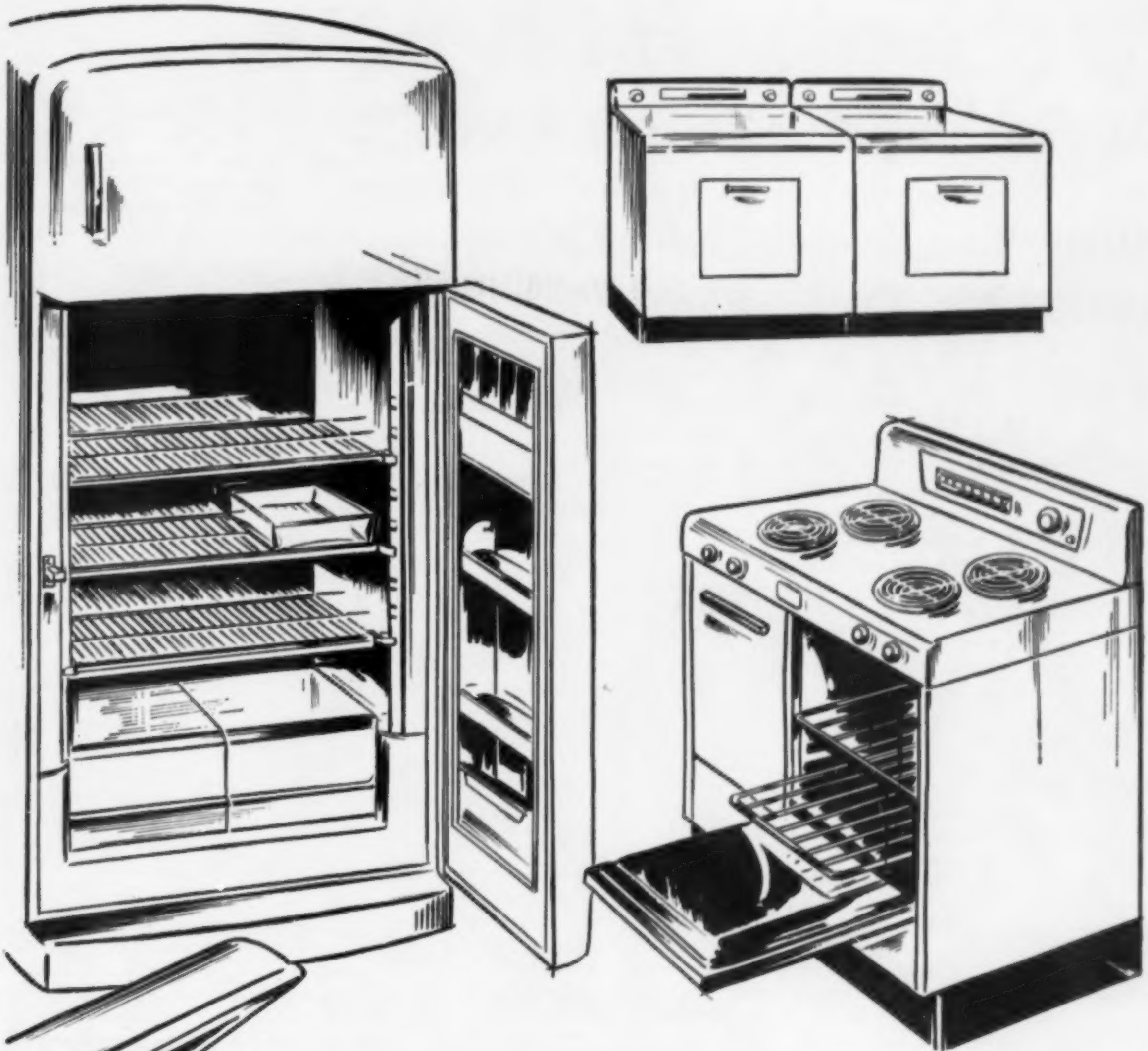
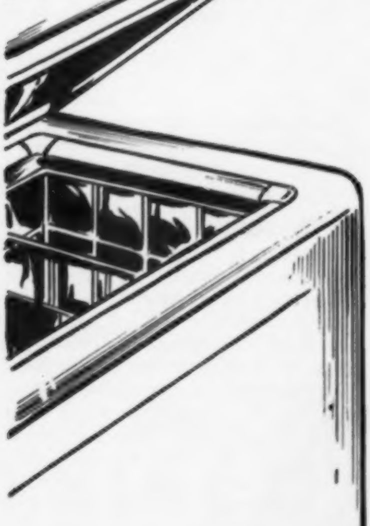




Special Reports
On Finishing Non-Ferrous Metals

NUMBER II—Paint Base, Corrosion-Resistant Finishing with Iridite

WHAT IS IRIDITE®?

Briefly, Iridite is the tradename for a specialized line of chromate conversion finishes. They are generally applied by dip, some by brush or spray, at or near room temperature, with automatic equipment or manual finishing facilities. During application, a chemical reaction occurs that produces a thin (.00002" max.) gel-like, complex chromate film of a non-porous nature on the surface of the metal. This film is an integral part of the metal itself, thus cannot flake, chip or peel. No special equipment, exhaust systems or specially trained personnel are required.

Chromate conversion coatings are well known and accepted throughout industry as an economical means of providing corrosion protection, a good paint base and decorative finishes for non-ferrous metals. However, continued developments have been so rapid and widespread that many manufacturers may not be completely aware of the breadth of application of this type of finish. Hence, this digest of current information; to bring you up to date on the many ways in which you can obtain proper surface preparation for painting and increase product durability with a single multi-purpose chemical pretreatment. Report I on decorative, corrosion-resistant finishes and Report III on chemically polished, corrosion-resistant finishes are available on request.

First, it is an accepted fact that metal surfaces should be prepared before painting to make possible an efficient paint system. Naturally, this preparation should provide for good initial paint adhesion. Chemical treatments have proved extremely effective in this respect, particularly those of a neutral or preferably acid nature. Further, to be most efficient, chemical treatments should provide a non-porous barrier to maintain adhesion by sealing the metal from the paint and moisture. They should also provide a self-healing film which prevents lateral corrosion in the event that bare metal is exposed through scratching.

The Iridite chromate conversion coatings meet all these requirements. Iridite is a chemical conversion treatment for surface preparation. It provides initial paint bonding by molecular adhesion. It is acid in nature and produces a film that is gel-like and non-porous in structure. Thus, the Iridite film effectively seals the metal from the paint and from moisture penetration. Because the film contains certain relatively soluble constituents, it will protect areas scratched through to bare metal and prevent lateral corrosion. This is accomplished by a gradual leaching of these constituents into the damaged area.

Further, because of its gel-like, non-crystalline nature, the Iridite film will not affect the appearance or texture of the paint film, nor will it dust or powder to mar the painted surface. Because the film is non-porous, paint coverage is increased, thus substantial savings in paint costs will be realized. In addition, treated parts may be stored for long periods of time prior to painting without the risk of entrapped moisture causing blistering when painting.

Iridite chromate conversion coatings are widely used with equal ease and success under both baked and air-dried paint systems. While the actual adherence properties of the Iridite film do not increase appreciably with its thickness, corrosion protection does. The protection of the Iridite film is proportionate to its thickness and should be taken into consideration when selecting the Iridite to meet your needs. However, it is sometimes necessary to sacrifice maximum corrosion protection for appearance when a finished part is to be only partially painted. For example, it may be desirable to use a thin, clear, bright Iridite film if the unpainted areas must present a chrome-like appearance. A typical case is that of instrument housings on which the exterior is painted and the inside left unpainted.

On the other hand, if all surfaces of the product are to be painted and maximum corrosion protection is required, the heavier and most protective Iridite films should be used. For example, all surfaces of zinc die cast fruit juicers are finished with a highly protective Iridite film prior to painting to provide maximum resistance to the corrosive action of fruit juices.

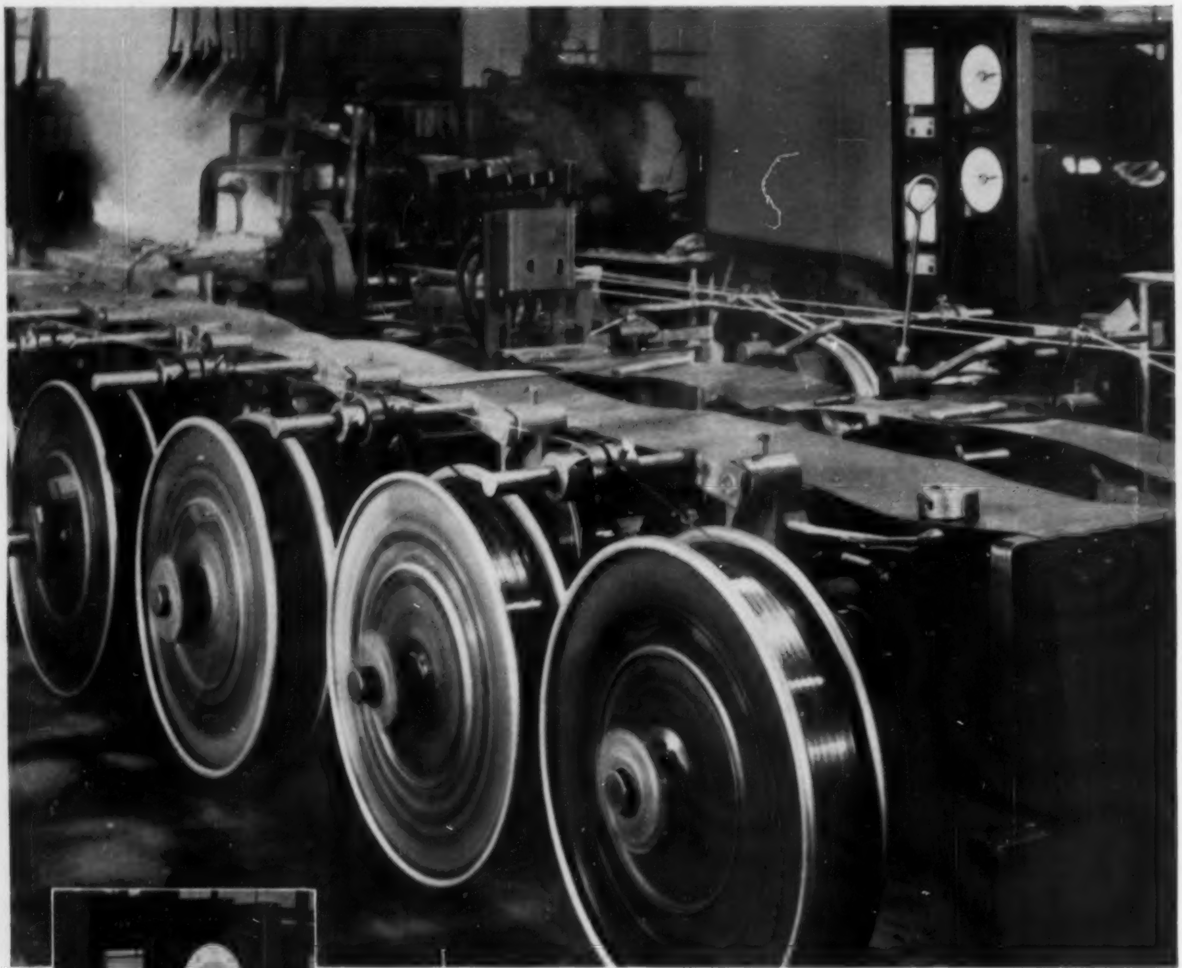
Iridite finishes are now available for all commercial forms of the more commonly used non-ferrous metals, including zinc, cadmium, aluminum, magnesium, silver, copper, brass and bronze. In addition to providing an excellent base for paint, the Iridite films also have high decorative value when used as final finishes in themselves.

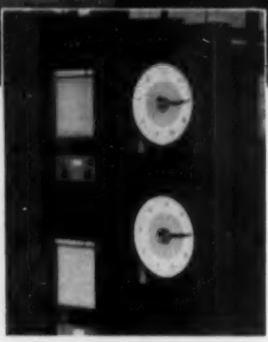
These films can produce a wide variety of pleasing appearances including clear bright, iridescent yellow, bronze, olive drab and brown. In addition, many films can be modified by bleaching or by dyeing. Among the dye colors available are various shades of red, yellow, green, blue or black.

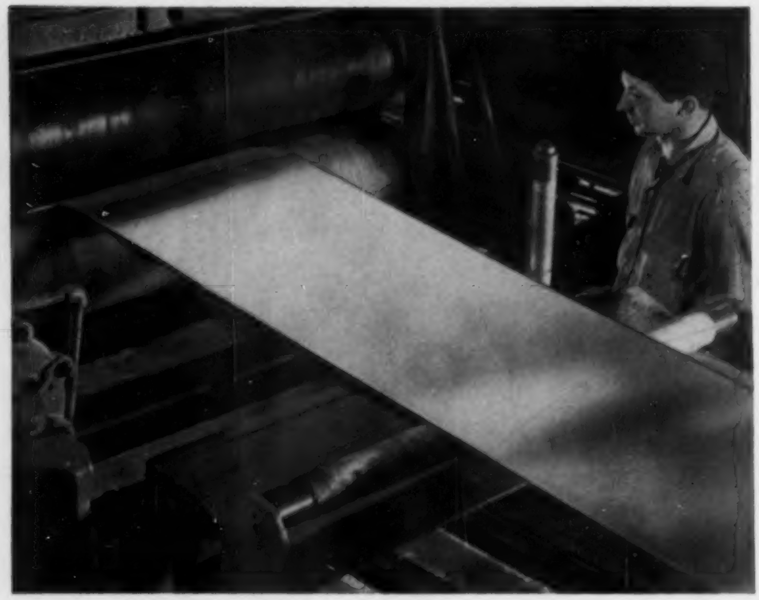
In planning or designing, you should consider the many other characteristics of Iridite finishes which may enter into the specific problem. In addition to their functions as protective and decorative finishes, and as bases for organic finishes and bonding compounds, Iridites have low electrical resistance. Some can be soldered and welded. The film does not affect the dimensional stability of close tolerance parts.

Iridites are widely approved under both Armed Services and industrial specifications because of performance, low cost and savings of materials and equipment.

You can see then, that with the many factors to be considered, selection of the Iridite best suited to your product requires the services of a specialist. That's why Allied maintains a staff of competent Field Engineers—to help you select the Iridite to make your installation most efficient in improving the quality of your product. You'll find your Allied Field Engineer listed under "Plating Supplies" in your classified telephone book. Or, write direct and tell us your problem. Complete literature and data, as well as sample part processing, is available. Allied Research Products, Inc., 4004-06 East Monument Street, Baltimore 5, Maryland.







TITANIUM STRIP is descaled continuously on time cycles as low as 30 seconds, with excellent results.

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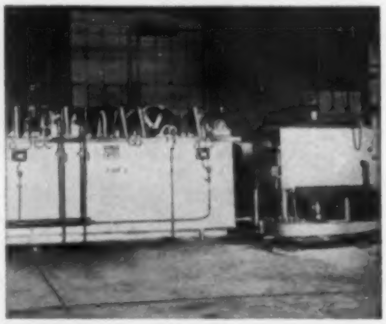
Descale alloy steels and titanium in any form—rapidly, safely—using the Hooker Process with Virgo® Descaling Salt.

A bath of molten Virgo Descaling Salt quickly converts scale, rust, and other surface impurities to an acid-soluble coating. A quench, acid dip, and final spraying then remove this coating in from one-tenth to one-hundredth the usual pickling time, with no measurable effect on the base metal.

You can easily set up the Hooker Process for batch or continuous operation on any form of work including strip, sheets, bars, wire, tubes, plate, castings, forgings, and fabricated parts. You can usually process work as fast as your handling methods allow, with a minimum of supervision. Operation is safe for personnel, and there is little or no spent-acid disposal problem.

You can profit by the experience of more than 50 companies now using the Hooker Process successfully to speed up descaling of alloy steels and titanium in practically every form.

You'll get quick service on any descaling problem, by writing or phoning us. Complete test and engineering facilities are at your disposal, without obligation.



LIGHT-GAUGE ALLOY STRIP is descaled at 20-35 ft. per min. in this Virgo bath, after annealing.

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STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.

Required by the Act of Congress of August 24, 1912, as amended by the Acts of March 3, 1933, and July 2, 1946 (Title 39, United States Code, Section 233) showing the ownership, management and circulation of **Metal Progress**, published monthly at Cleveland, Ohio, for October 1, 1956.

1. The names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, American Society for Metals, 7301 Euclid Ave., Cleveland 3, Ohio; Editor, E. E. Thum, 7301 Euclid Ave., Cleveland 3, Ohio; Managing Editor, M. R. Hyslop, 7301 Euclid Ave., Cleveland 3, Ohio; Business Manager, W. H. Eisenman, 7301 Euclid Ave., Cleveland 3, Ohio.

2. The owner is: (if owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding 1 per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a partnership or other unincorporated firm, its name and address, as well as that of each individual member, must be given). The American Society for Metals, 7301 Euclid Ave., Cleveland, which is an educational institution, the officers being: President, Donald S. Clark; Vice President, G. M. Young; Secretary, W. H. Eisenman; Treasurer, C. H. Long; Trustees: A. O. Schaefer, H. A. Wilhelm, G. E. Shubrooks, G. A. Fisher, and Carl E. Swartz. All officers as above, 7301 Euclid Ave., Cleveland 3, Ohio.

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5. The average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the 12 months preceding the date shown above was: (This information is required from daily, weekly, semiweekly, and tri-weekly newspapers only).

E. E. Thum,
Editor.

(Seal)

Sworn to and subscribed before me this 19th day of Oct. 1956.

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Notary Public.

(My commission expires May 19, 1957.)

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